BBC

YOUR GUIDE TO AUTUMN'S BEST STARGAZING

#220 SEPTEMBER 2023

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

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Osiris-Rex returns to Earth with secrets from another world

BINOCULAR BEAUTIES

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10 GREAT ASTROPHOTO TARGETS FOR BEGINNERS

FINDING INSPIRATION IN THE HUNT FOR AURORA

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Welcome

We're about to get a delivery from another world

Later this month, OSIRIS-REx will return to Earth and complete the final stage of its seven-year-long mission by sending a small circular capsule down from orbit to land in the deserts of Utah. Inside is an important payload: pristine sample material collected from its target in deep space, asteroid Bennu. In our feature on **page 66**, features editor Ezzy Pearson looks at what will happen to these samples from another world once they're back on Earth and the secrets that planetary scientists expect the space rocks to reveal about the early Solar System.

If the OSIRIS-REx capsule's fiery descent through Earth's atmosphere was to happen at night and in a less remote location, it may well have made it into our feature on **page 34** too. Here, astronomer and writer Tom Kerss is our guide to 10 top targets to get started in astrophotography. The subjects he's chosen are great for first-time imagers and cover a range of equipment, from a smartphone on a tripod to a DSLR camera attached to a telescope. If you've not tried capturing the night sky before, it will give you the inspiration to get started!

As the nights lengthen in September and dark-sky season returns, it's the perfect time to try out astrophotography. On **page 28** we've also got an overview of the great observing targets coming up right across autumn, where astronomy writer Katrin Raynor has picked out the constellations, planets and special events you'll really want to make time for. There's a lot to keep looking up for!

Chris Bramley, Editor

PS Our next issue goes on sale on Friday 15 September.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more

Social media
Follow us on Twitter, Facebook and Instagram for space news, astro images and website updates

Podcasts
Discover the best things to see in the night sky every week by listening to our Star Diary podcast

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Get each month's issue on your Apple or Android device, now with bonus image galleries

eNewsletter
The best targets to observe each week, delivered to your inbox. Visit **bit.ly/skynewsletter**

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66

CONTENTS

C = on the cover

Features

Regulars

Astrophotography

Reviews

The Sky Guide

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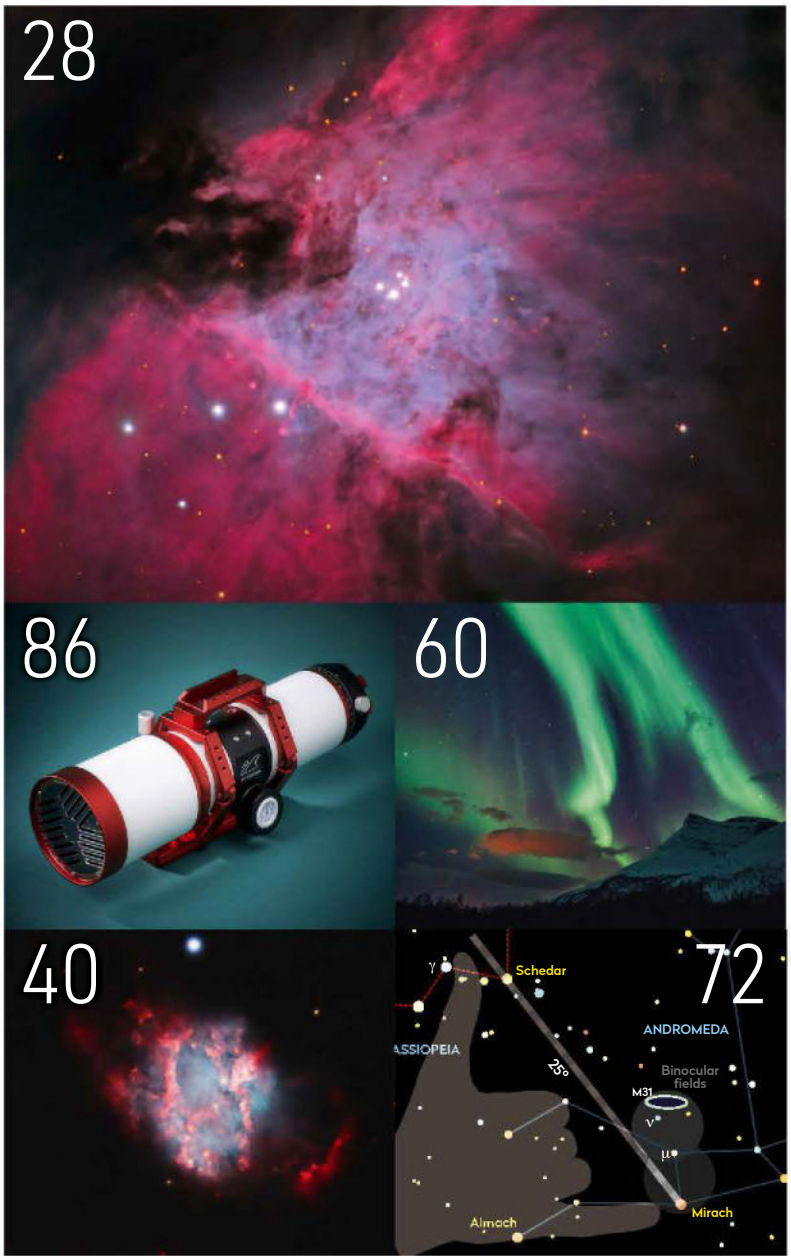
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Katrin Raynor

Astronomy writer

"Darker skies are on their way and there's a lot to look forward to, including a comet, a partial lunar eclipse and the return of every stargazer's favourite, Orion". **Discover autumn's unmissable sights on page 28**

Ezzy Pearson

Features editor

"OSIRIS-REx is the latest mission to bring back pieces of space rock, but it won't be the last. With missions heading to the Moon and Mars, it's an exciting time for sample returns!" **Read all about the rock hunters on page 66**

Steve Tonkin

Binocular astronomer

"Star-hopping not only helps you navigate the night sky with ease, it also helps you learn how constellations relate to each other. You'll quickly build up a familiarity with the night sky." **Learn how to do it on page 72**

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/RQ3L6T5/** to access this month's selection of exclusive Bonus Content

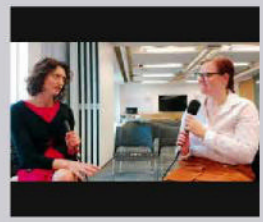
SEPTEMBER HIGHLIGHTS

Interview: Pulsars and spacetime ripples

Dr Michael Keith explains how changes in spinning stars called pulsars help us detect gravitational waves.

Is There Anybody Out There?

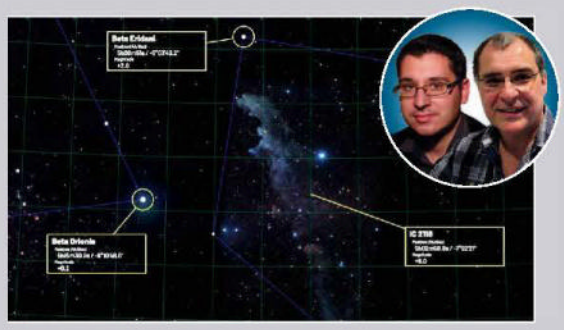
Watch this episode of *The Sky at Night* which explores how we might communicate with extraterrestrial life.



Interview: Echo of the Big Bang

Cosmologist Erminia Calabrese reveals how the cosmic microwave background can be used to study the Universe.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

CAT AMONGST THE COSMOS

A closer look at the gigantic star-forming region known as the Smiling Cat Nebula

VLT SURVEY TELESCOPE, 27 JUNE 2023

Contrary to popular myth, not all ginger cats are toms. Some are female – and some, like Sh2-284, are huge swirling clouds of gas and dust located some 15,000 lightyears from Earth in the constellation of Monoceros.

Pictured here in sharper detail than ever before, thanks to the efforts of scientists working at the VLT Survey Telescope on Cerro Paranal, Chile, the stellar nursery known as Sh2-284 has been nicknamed the Smiling Cat Nebula thanks to its (admittedly somewhat tenuous) resemblance to a feline face. At its heart – or just below the cat's nose, if you will – lies a cluster of young stars called Dolidze 25. Hydrogen in the surrounding gas and dust clouds is ionised by the radiation coming from powerful, energetic newborn stars, giving the nebula its distinctive orange colour.

MORE **ONLINE**

Explore a gallery of these and more stunning space images

ESO/VPHAS+ TEAM. ACKNOWLEDGEMENT: CASU

△ Spectacular star birth

JAMES WEBB SPACE TELESCOPE, 12 JULY 2023

Released to mark Webb's first year of science, this image shows Rho Ophiuchi – the closest star-forming region to Earth – in startling detail. Perhaps most striking are the red jets of hydrogen that criss-cross the image, each emitted from a newborn, Sun-like star. Larger star S1, meanwhile, has carved out a 'cave' in the surrounding dust.

Dazzling Dimorphos ▷

HUBBLE SPACE TELESCOPE, 19 DECEMBER 2022

Several months after NASA's DART mission (Double Asteroid Redirection Test) struck the asteroid Dimorphos, the Hubble Space Telescope was able to capture the sparkling halo of boulders flung from the surface during the collision. The rocks measure between one and six metres across, and are drifting away at just under 1km/h.

Stellar photobomber ▷

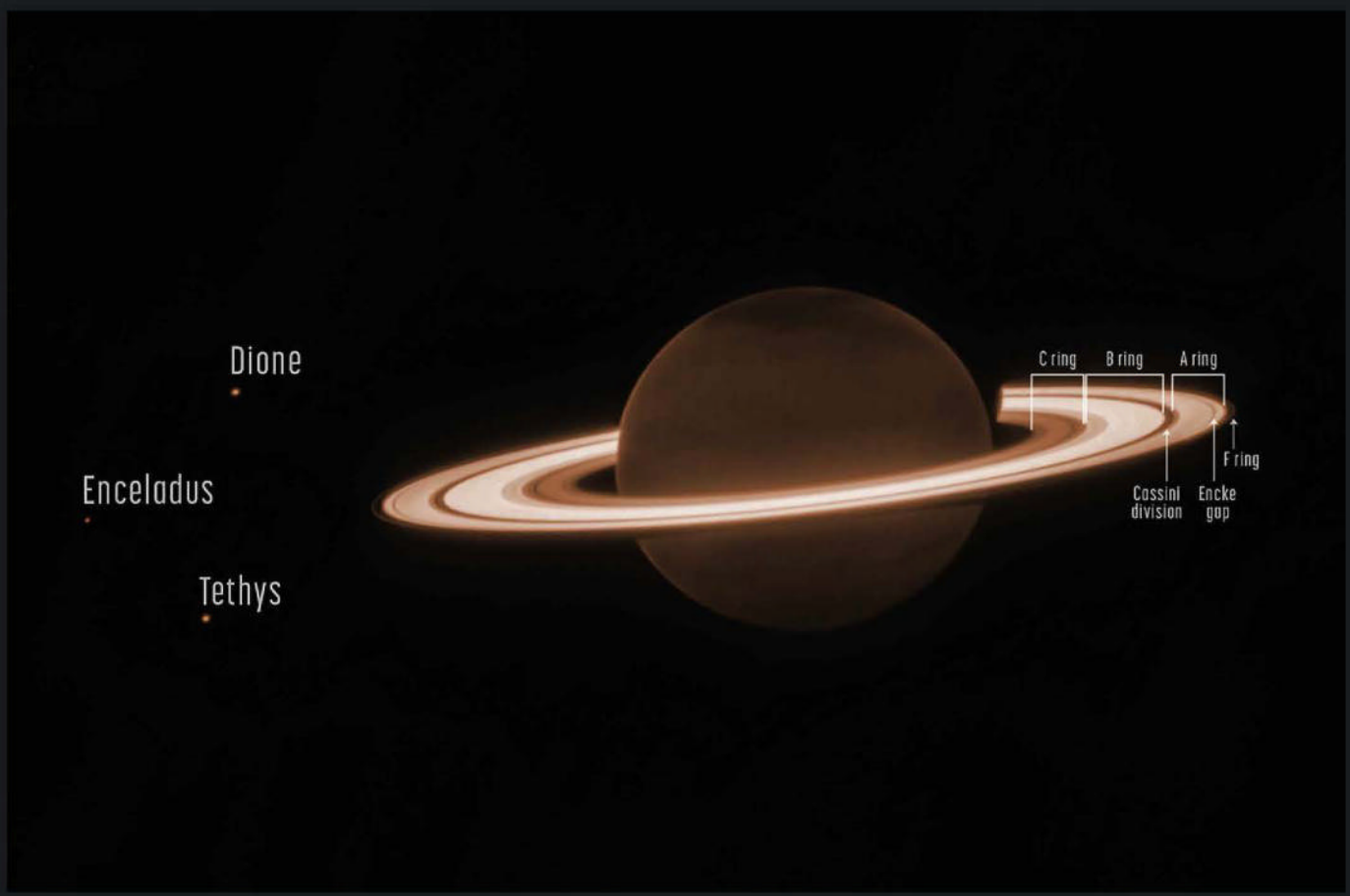
HUBBLE SPACE TELESCOPE, 17 JULY 2023

This image of galaxy Arp 263 was created by combining data from Hubble's Wide Field Camera 3 and Advanced Camera for Surveys. This revealed Arp 263's ragged shape in fine detail – but also meant that foreground star BD+17 2217 ended up with eight diffraction spikes rather than four, leading to it stealing the show...

The dark mystery of Saturn ▽

JAMES WEBB SPACE TELESCOPE, 25 JUNE 2023

Webb's wonderful capture of Saturn shows the planet's A, B, C and F rings as well as moons Dione, Enceladus and Tethys. But it's the darker area towards the north pole, which is currently experiencing summer, that's puzzling scientists. NASA suggests this may be due to "an unknown seasonal process affecting polar aerosols".



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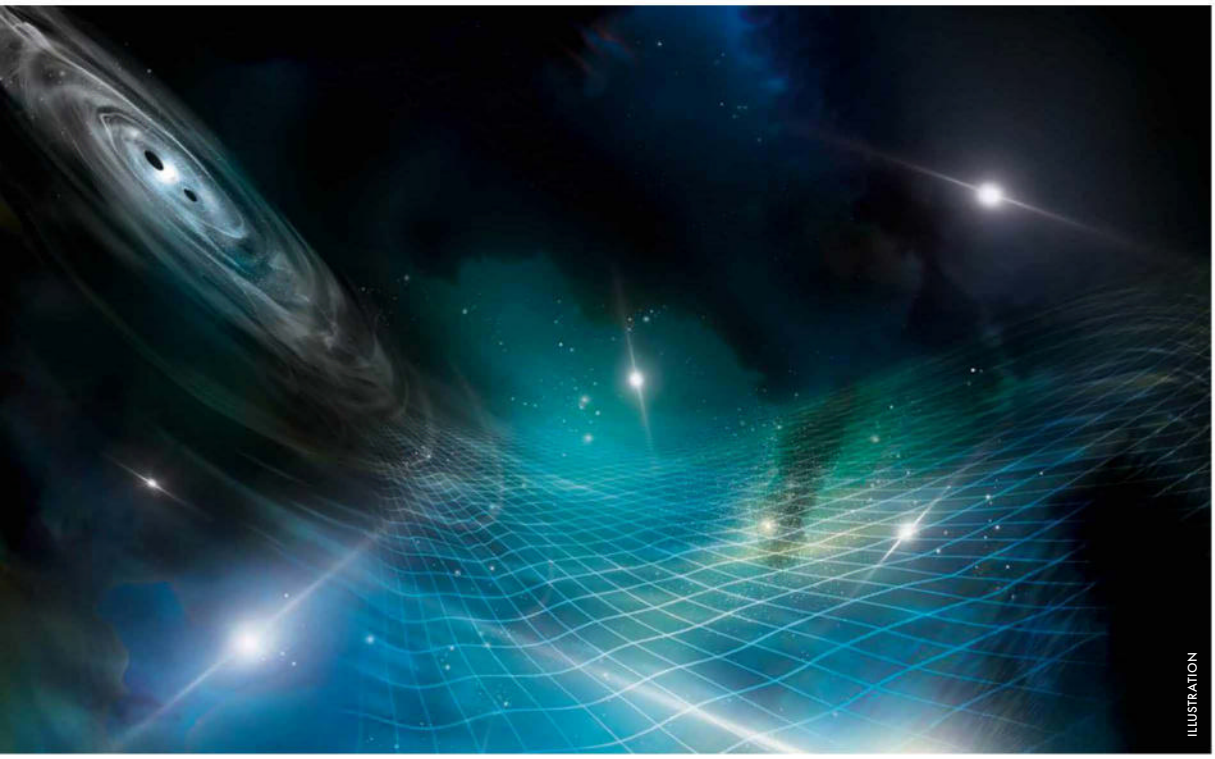
The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



ILLUSTRATION

▲ **Waves from massive black hole collisions may be behind disruptions heard in the regular beat of pulsars**

Giant black holes heard colliding

Gravitational waves give scientists new insight into how galaxies grow

A telescope the size of a galaxy and created using long-dead stars has found the best evidence yet of the background hum of gravitational waves created by merging supermassive black holes, providing a window into this mysterious process.

The signals have such a low frequency it takes years to complete a single wave. Because of this, two different teams of astronomers, the US-based NANOGrav and a collaboration between the European and Indian Pulsar Timing Arrays, have been collecting data for 15 and 25 years respectively.

The teams used dozens of microsecond pulsars – neutron stars which both spin multiple times a second and emit powerful beams of radiation. When one of these beams sweeps over Earth we see a flash, much like a lighthouse. The timing of these flashes forms one of the most reliable clocks in the cosmos. However, when a gravitational wave passes by it can create slight changes in their timings, which the teams were able to use to detect the waves.

"Pulsars are actually very faint radio sources, so we require thousands of hours a year on the world's largest telescopes to carry out this experiment," says Maura McLaughlin from West Virginia University and co-director of NANOGrav.

The signal matches simulations of supermassive black hole binary systems created when two galaxies merge. This process is not well understood and difficult to observe traditionally, meaning these waves could provide key insights into what happens when giant black holes come together.

"That is definitely our best guess, and it's fully consistent with the data, but we're not positive," said Luke Kelley from University of California, Berkeley and part of the NANOGrav group. "If it is binaries, then that's the first time that we've actually confirmed that supermassive black hole binaries exist, which has been a huge puzzle for more than 50 years now."

www.nanograv.org

AURORE SIMONNET, NANOGRAV COLLABORATION

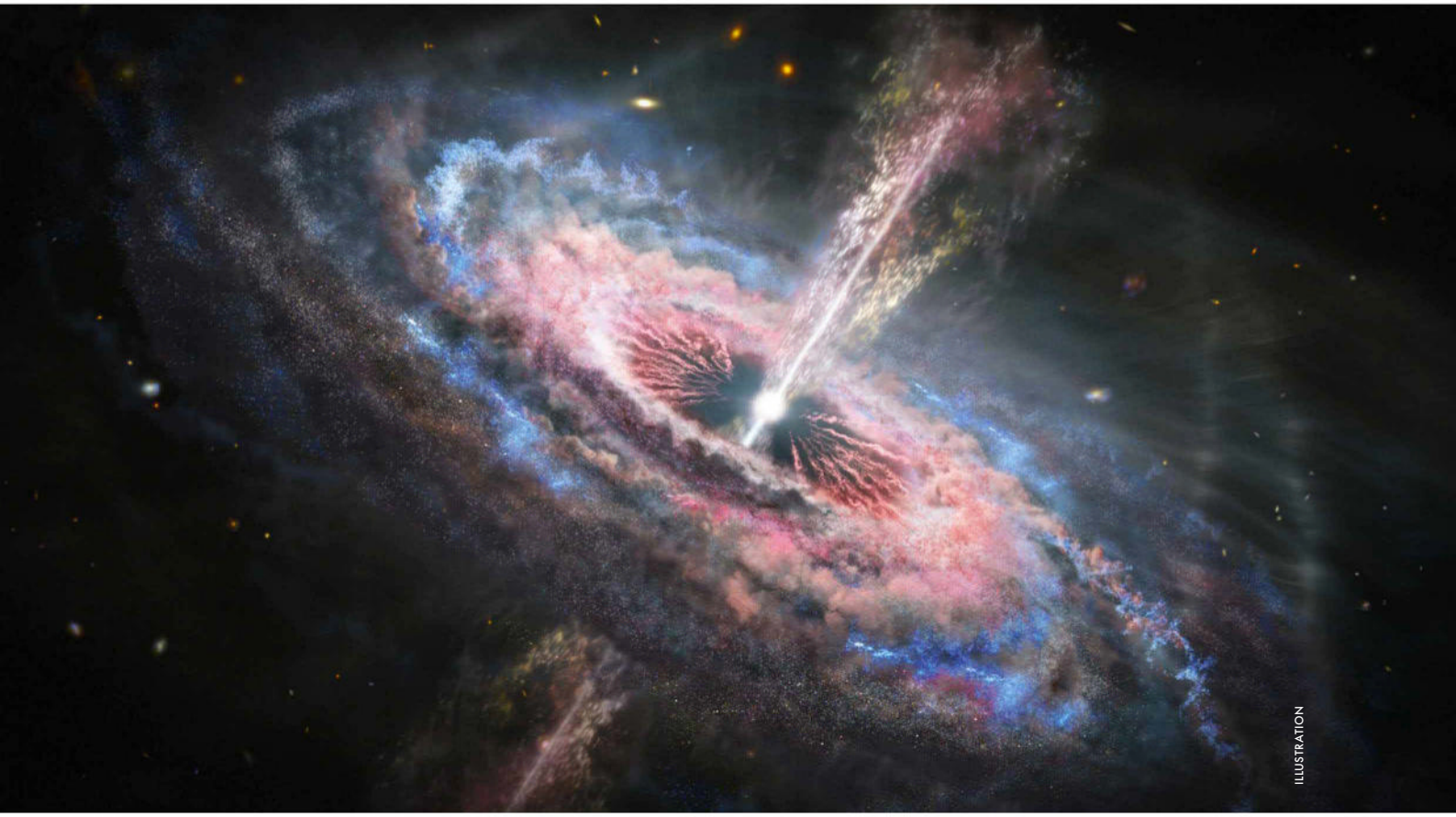
Comment

by Chris Lintott

These new results will teach us a huge amount about supermassive black holes and the environments they live in near the centres of galaxies.

Remarkably, we've also learnt a bit about the Solar System along the way. The signal the gravitational wave hunters are looking for is very sensitive to the movement of Earth – and our planet is pulled this way and that not only by the Sun, but also by the other planets. These new results depend particularly on tracking the orbit of Jupiter. Together with the pulsar work, the team measured the position of the Solar System's barycentre – the point around which we orbit – to a precision of 100 metres – a little more than the length of a football pitch. Astonishing.

Chris Lintott co-presents *The Sky at Night*



▲ **Timing is everything: researchers used the 'tick' of 190 quasars as a yardstick for measuring the slowdown of time**

Early Universe seen running slow

Cosmic clocks appear to run slower soon after the Big Bang, just as Einstein predicted

Astronomers have for the first time captured the early Universe running in extreme slow motion – just as Einstein's theory of relativity predicted – a new study has revealed. The researchers observed the phenomenon by using quasars, the supermassive black holes at the centres of early galaxies, as 'clocks'.

The further we look into the Universe, the longer the light takes to travel the distance to reach us, potentially taking billions of years when we look back into the most distant Universe. As well as giving us a way to see what the Universe looked like billions of years ago, it also presents a unique opportunity to see relativity in action.

"Thanks to Einstein, we know that time and space are intertwined and since the dawn of time, in the singularity of the Big Bang, the Universe has been expanding," says Geraint Lewis from the University of Sydney, who led the study. "This expansion of space means that our observations of the early Universe should appear to be much slower than time flows today. If you were there, in this infant Universe, one second would seem like one second – but from our position, more than 12 billion years into the future, that early time appears to drag."

Previous studies have been able to see this effect out to around half the age of the Universe using supernovae, but these aren't bright enough to provide measurements to earlier dates.

Lewis's team instead used measurements of the fluctuating brightness of 190 bright galaxies known as quasars, which could be used as cosmic clocks. By measuring out how long each quasar took to 'tick', it was possible to work out how much of a time-dilation effect they had experienced due to the expansion of space.

As quasars are much more complex objects than supernovae, they were considerably more difficult to use as clocks. Lewis's team had to draw from two decades' worth of observations across multiple wavelengths to gain enough data to standardise the quasar's timing.

"With these new data and analysis, we've been able to find the elusive tick of the quasars, and they behave just as Einstein's relativity predicts," says Lewis. "Looking back to a time when the Universe was just over a billion years old, we see time appearing to flow five times slower." **www.sydney.edu.au**

NASA/ ESA/ J. OLMSTED (STSCI), NASA/JPL-CALTECH/MSSS, ISRO OFFICIAL, UNIVERSITY OF WARWICK/MARK A. GARLICK

A drill hole in Jezero Crater, where the rover has found multiple organic samples

Perseverance captures a cocktail of organics

The molecules could indicate Mars was once habitable

NASA's Perseverance rover has found potential signs of a complex mixture of organic molecules – the building blocks of life – in at least 10 of the sites it has taken samples from, it was recently revealed.

Organics are molecules containing carbon and hydrogen, which are critical for all life on Earth. Perseverance is currently hunting for organics in Jezero Crater, a region thought to be the site of an ancient lake. So far, it has found a variety of organics at every sample site in two different locations, though geologists won't be able to identify exactly which until the samples are returned to Earth in the mid-2030s.

"The detection of diverse organics in... ancient lakes on Mars is important for understanding the extent and diversity of Martian surface processes and how this relates to habitability and potential life detection," says Ashley E Murphy from the Planetary Science Institute. **www.mars.nasa.gov/mars2020**

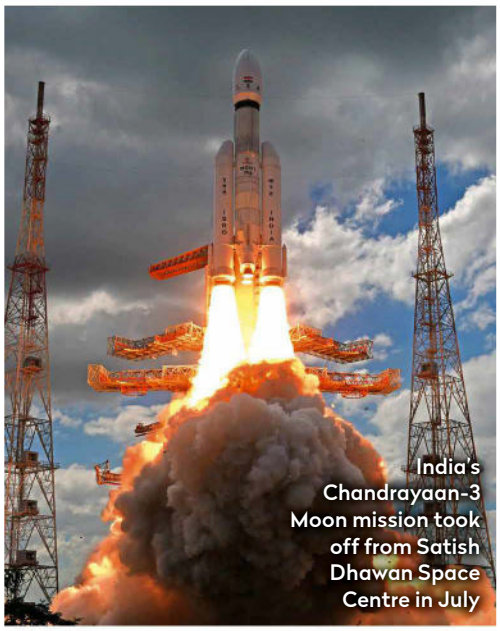
▶ Turn to page 66 to read more about sample-return missions

Two major missions commence

July saw the successful launch of two major space missions: the European Space Agency's (ESA) Euclid and the Indian Space Research Organisation's (ISRO) Chandrayaan-3 mission to the Moon.

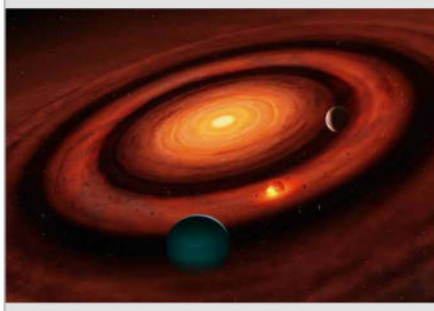
Euclid launched on 1 July at 16:12 BST, heading towards L2, a gravitationally stable orbit around the Sun. The spacecraft will spend at least six years creating a map of the cosmos at large scales. Astronomers will use this data to investigate the 'dark Universe', exploring how the role of gravity, dark matter and dark energy have shaped the cosmos over time.

Two weeks later, on 14 July, the Indian Chandrayaan-3 lunar mission launched at 10:05 BST, setting course for the Moon shortly afterwards. The mission is a follow-up to a previous landing attempt that failed in September 2019 following a software glitch. With this latest launch, ISRO is reattempting the feat – its Vikram lander is scheduled to set down in the lunar south pole on 23 August. The chosen site is where the Chandrayaan-1 orbiter found evidence of water deposits back in 2009.


India's Chandrayaan-3 Moon mission took off from Satish Dhawan Space Centre in July

On completion of a successful touchdown, the lander will deploy its Pragyan rover to explore the lunar surface.

NEWS IN BRIEF



Sandwich planets

As larger planets grow in their protoplanetary discs, they could shepherd the flow of dust, leading to the formation of a smaller planet between them, it was recently discovered. This 'sandwiched' planet formation could be responsible for the rings seen in the discs, where the dust has been cleared from a specific region.

Ham radios find solar flares

Shortwave 'ham' radio operators around the world have begun experimenting with a new way of detecting solar flares. Shortwave radios bounce signals off the ionosphere; when this layer of the atmosphere is hit by a solar flare it expands, doppler-shifting the signals, thus revealing solar activity. Visit **hamsci.org** for details.

Planetary spiral

Giant exoplanets are responsible for sending their protoplanetary discs into a spin, it has now been confirmed. Spiral structures have been seen in planet-forming regions since 2013, but recently-discovered MWC 758c has now been caught in the act of creating one in its home system.

NEWS IN BRIEF


ILLUSTRATION

Mars return costs mount

NASA's Mars Sample Return programme could cost far more than previous estimates allowed. A new independent review suggests the mission to retrieve the samples being collected by Perseverance – which is being jointly developed with ESA – could cost up to $10 billion, over double initial forecasts.

Cosmic chains

A long, narrow filament of 10 galaxies dating from just 830 million years after the Big Bang has been seen by the JWST for the first time. Our current-day Universe is organised into a cosmic web, with chains of galaxies linking massive clusters and it's thought this structure is an early thread in that web.

Stellar destruction derby

A never-before-seen kind of stellar death could be responsible for a recent gamma-ray burst seen by Gemini South telescope. Astronomers believe the GRB was created by two stars in the dense region around a black hole, where they are so tightly packed they are driven to collide and destroy each other.

BULLETIN

Electron rain creates Mercury's aurorae

The X-ray aurorae are triggered by solar wind hitting the planet


The mechanism that creates aurorae seems to be the same throughout the Solar System
ILLUSTRATION

The mystery of Mercury's aurorae has finally been solved with the help of data taken during the first fly-by of the European-Japanese BepiColumbo mission. The mission won't enter orbit until 2025, but it passed just 200km from the surface on 1 October 2021.

Mercury's X-ray aurorae were first seen by NASA's MESSENGER probe. On Earth, the solar wind interacting with the outer atmosphere is responsible for the aurorae, but as Mercury's atmosphere is very thin it was unclear how it could have its own aurorae. During its fly-by, BepiColumbo measured the flow of charged particles around the planet, finding electrons caught up in the magnetosphere on the dawn side were being transported to the tail region of the planet, where they rained down on the surface. With no atmosphere to stop them, they interacted directly with the surface, emitting X-rays.

"While Mercury's magnetosphere is much smaller than Earth's and has a different structure and dynamics, we have confirmation that the mechanism that generates aurorae is the same throughout the Solar System," says Sae Aizawa from Institut de Recherche en Astrophysique et Planétologie, France.

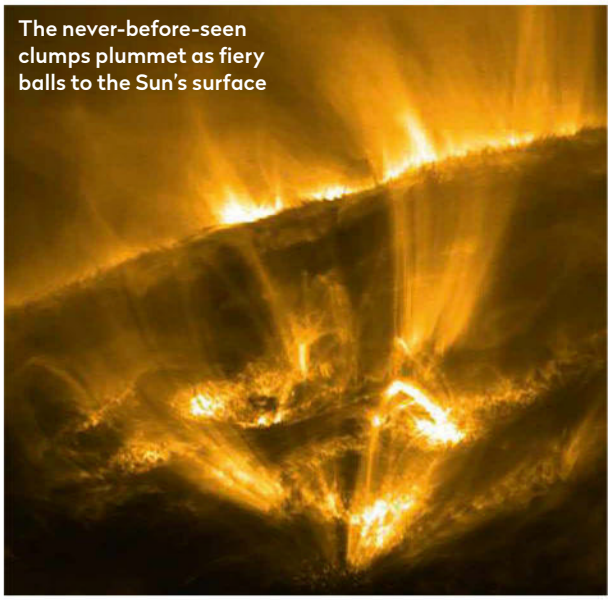
mio.isas.jaxa.jp/en

Fireballs rain down from Sun's corona

A phenomenon known as 'coronal rain', where meteor-like fireballs fall to the solar surface, has been spotted for the first time by ESA's Solar Orbiter (SolO).

The 'rain' is actually solar material originally from the corona, the outermost part of the Sun's atmosphere. The region is usually a million degrees in temperature, but sudden, localised temperature drops can create clumps of plasma measuring up to 250km wide, which gravity then pulls towards the Sun at over 100km/s. As these fireballs fall, they heat and compress the gas beneath them, causing spikes of intensity up to a million degrees which the SolO was able to detect.

"SolO orbits close enough to the Sun that it can detect small-scale phenomena occurring within the corona, such as the effect of the rain on the corona. This allows us a precious indirect probe of the coronal environment that is crucial to understanding its composition and thermodynamics," says Patrick Antolin from the University of Newcastle, who led the study. "Just detecting coronal rain is a huge step forward for solar physics because it gives us important clues about the major solar mysteries, such as how it is heated to millions of degrees."


The never-before-seen clumps plummet as fiery balls to the Sun's surface

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Our experts examine the hottest new research

CUTTING EDGE

Ring the changes: ancient Juniper trees point to unusual patterns in Earth's past climate

2,000-year-old trees are unlikely astronomers

Tibetan Juniper trees could trace millennia-long patterns of solar activity

While astrology is nonsense, Earth and the life on it are certainly deeply affected by cosmic influences. For example, variations in the eccentricity of our planet's elliptical orbit around the Sun, as well as the tilt of its spin axis, are driven by the shifting balance of gravitational tugs from the Moon and the Sun, as well as the giant outer planets, especially Jupiter. These so-called Milankovitch cycles cause rhythmical variations in the intensity of the seasons and Earth's overall climate. The pulse of ice ages over the past 2.5 million years, for instance, is governed by the Milankovitch cycles. Slight variations in the Sun may also affect climate in smaller ways, such as periods when the solar magnetic field is weaker – meaning there are fewer sunspots – allow more galactic cosmic rays to reach Earth, potentially triggering greater cloud formation.

Scientists studying Earth's past climatic conditions rely on various sources of information, such as the ratio of different isotopes in Antarctic ice cores, sediments at the bottom of lakes and oceans, and tree rings. Trees are sensitive to factors such as temperature and rainfall, so the rings of growth they produce in their branches and trunks each year serve as recorders of that area's local climate: tree rings are generally thicker in warm and wet years. Tree ring data may therefore reveal shorter-term patterns of variation in Earth's climate.

Vincent Courtillot and his colleagues at the Paris Institute of Earth Physics, Paris Cité University, have been studying a very special tree ring data set made available by Ouya Fang at the Chinese Academy of Sciences, Beijing. Juniper trees in the Dulan forest grow high on the northern Tibetan plateau, at altitudes between 3,000 and 4,500 metres above sea level. This remoteness means these trees have been minimally affected by human influence throughout their lifespans, which range from 15 to 1,967 years old.

The team performed a statistical analysis of the thickness of growth rings in 469 trees and were able to identify a set of periodic variations over short timescales. From this they found evidence of several repeating patterns within the ring thicknesses. Two of these, with a period of 11 and 85 years, match up with patterns found from studying changes in sunspot numbers, named the Schwabe cycle and Gliessberg cycle respectively. But the researchers also found a number of other cycles with periods between 3.3 years and more than 1,000 years, with as-yet unknown causes.

> ***"Their analysis of these tree rings reveals there could be much shorter cycles varying over centuries or even years"***

The well-known Milankovitch cycles operate over timescales of tens or hundreds of thousands of years, but Courtillot and his colleagues argue that their analysis of these tree rings reveal there could be much shorter cycles varying over centuries or even years. This is a controversial claim, and whether these shorter-timescale cycles are genuine or not will likely come out in the wash with further research. But the statistical analysis of the growth rings of such unique, ancient trees holds great promise for better understanding our planet's climatic history. Courtillot describes these Tibetan junipers as "astro-geophysical observatories" – offering an intriguing link between living organisms and cosmic influences on Earth's climate.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *A Living Forest of Tibetan Juniper Trees as a New Kind of Astronomical and Geophysical Observatory* by Vincent Courtillot et al. **Read it online at: arxiv.org/abs/2306.11450**

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Stellar fireworks confuse JWST

Early galaxies may conceal their real mass behind bursts of new stars

A year into what will hopefully be a 20-year mission, JWST has given us spectacular images of everything from Jupiter to the Orion Nebula. Yet the results that have attracted some of the most attention – images of what seem to be the most distant galaxies ever seen – are hardly spectacular. Though it's impressive that the light from each of these galaxies has been travelling towards us for more than 13 billion years, so that we see them as they were just as the Universe was getting started, the truth is that we see them as nothing more than faint blobs.

So what can we really know about a galaxy when all we have is a blurry, blobby image? Obtaining spectra – where we measure out the intensity of light at various wavelengths – will help, not least because we can use features within this spectra to measure its redshift, and so determine how far away it is. But what we really want to know is what these baby galaxies are like. Have they formed stars, and when? Do they already host giant black holes?

Early results suggest that the galaxies may be much more developed than we expect, but this month's paper casts doubt on these headline results. A team led by Desika Narayanan from the University of Florida, as well as astronomers in Edinburgh and Portsmouth, have been using powerful computer simulations to test the limits of our telescopes, pointing a virtual JWST at synthetic galaxies to see what can be discovered. Though the results are still being reviewed by a journal, the news is slightly alarming.

One of the most important things we want to know is the mass of all the stars that have formed in the few hundred million years between the Big Bang and the light we see today leaving the galaxy. This is predicted by cosmology and gives us a sense of how the great project of assembling the massive systems, including galaxies like our own Milky Way, is going. The trouble is, this paper shows that we are easily distracted if we happen to view the galaxy just as it is experiencing a new burst of star formation.

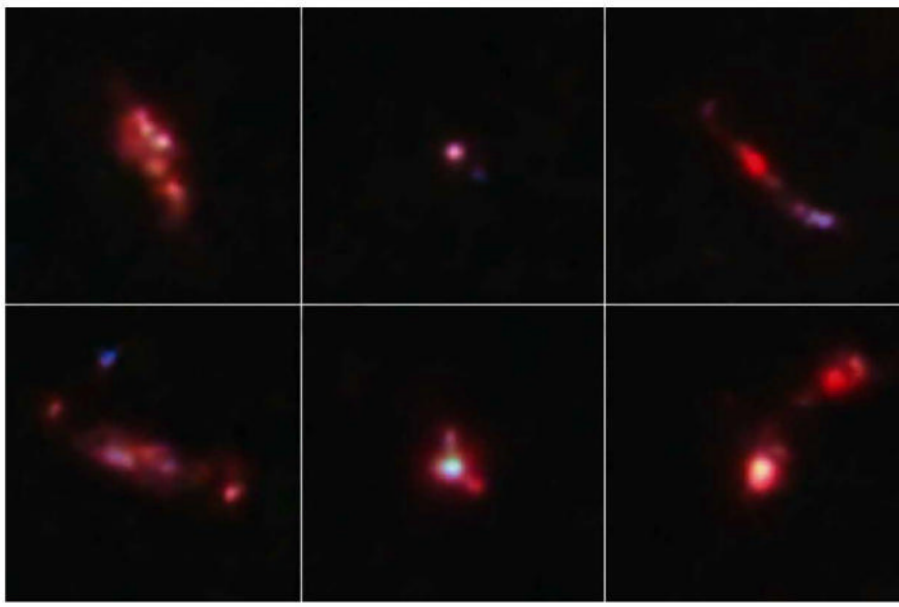
Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Some of the stars created during the burst are massive. These live fast and die young, so don't persist long after the star formation has stopped. However, during the burst, their bright light can outshine and wash out the background light from more long-standing members of the galactic population. In other words, we might think we're observing the main disc of the galaxy, but instead we're only seeing fireworks of new stellar growth happening over the top.

This means that our estimate of their mass might be wrong by a factor of 10 or so, with the problem being worse for systems where stars form in bursts – something some expect in the early Universe. This is an enormous error and threatens to derail our ability to test cosmology using deep JWST observations.

"We think we're observing the main disc of the galaxy, but we're only seeing fireworks of new stellar growth happening over the top"

There is some hope. The authors suggest that more sophisticated models of how the star formation history of a galaxy relates to its spectra, perhaps developed with the help of machine learning, might be the solution. But in the meantime, this is another reason to be careful in interpreting what JWST is seeing in the early Universe. That's okay though – we have a long mission ahead to figure these things out.

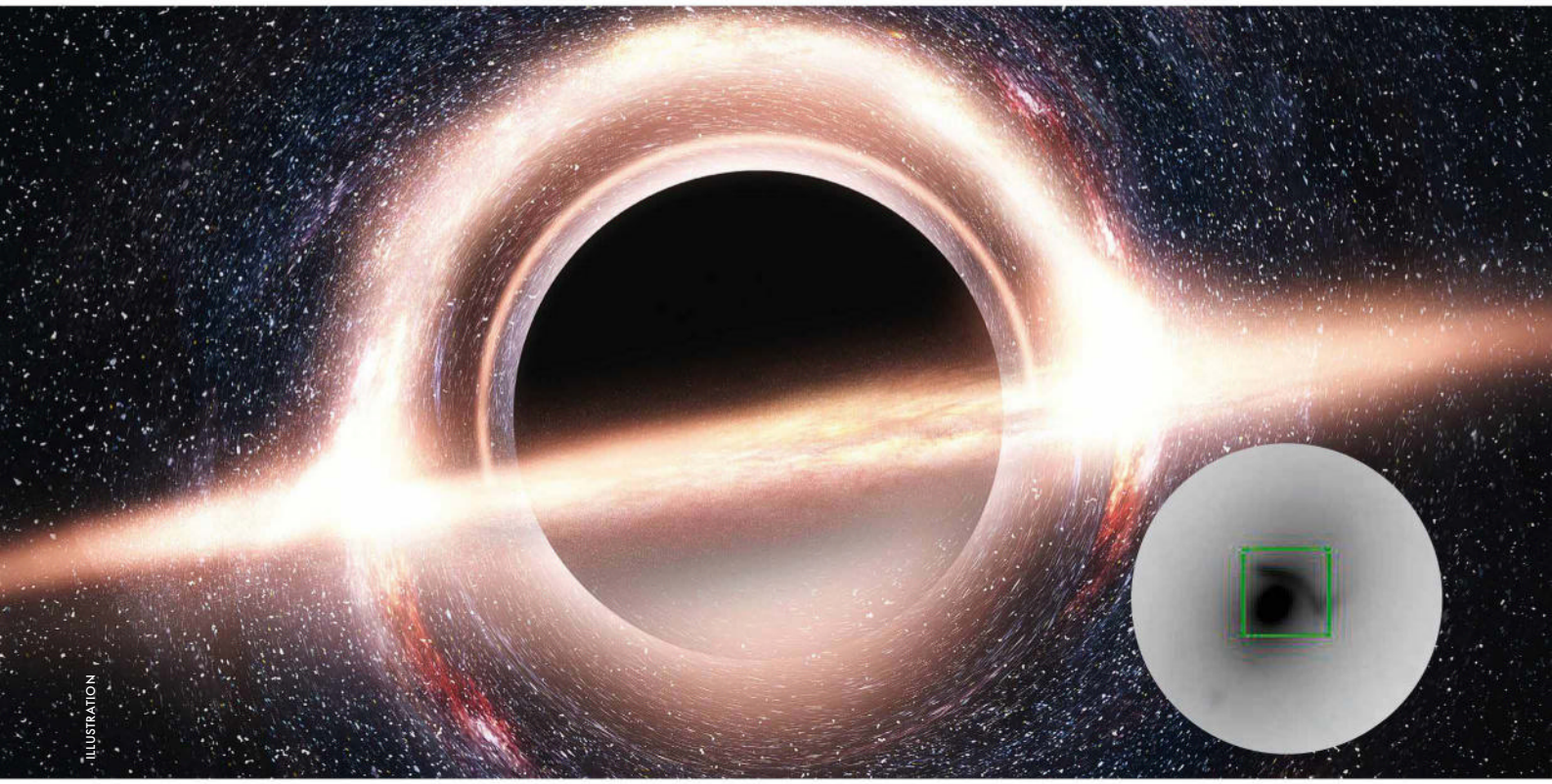


▲ **Six galaxies just 900 million years after the Big Bang – but bright blasts of shortlived star formation could be hiding the real view from JWST**

Chris Lintott was reading... *Outshining by Recent Star Formation Prevents the Accurate Measurement of High-z Galaxy Stellar Masses* by Desika Narayanan et al. **Read it online at: arxiv.org/abs/2306.10118**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



ILLUSTRATION

In this month's episode of *The Sky at Night*, **James Nightingale** explains how to find invisible black holes using the light that bends around them

One of astronomy's most astonishing recent discoveries is a supermassive black hole (SMBH) named Sagittarius A* at the centre of our Galaxy, with a mass exceeding one million times that of our Sun. Astronomers have since revealed that SMBHs inhabit the cores of many more distant galaxies, suggesting that a SMBH resides at the heart of almost every galaxy in the Universe.

To study these enigmatic objects, astronomers map out the orbits of stars in nearby galaxies. They observe a distinctive peak in the stellar velocities near the galactic centre, indicative of the intense gravitational force exerted by the SMBH. In more distant galaxies, their central SMBH may be 'active', where the surrounding material is moving so fast that it gets hot enough to give off bright emissions across the full electromagnetic spectrum, from gamma rays to the radio. By studying the relativistic effects of the black hole's gravity on this emission, astronomers can once again deduce its mass.

Put simply, the larger the galaxy, the more massive its black hole tends to be. In fact, the most colossal black holes ever discovered, known as ultramassive black holes, take up residence in the cores of the most massive galaxies.

One burning question remains: How enormous can black holes truly be? This poses a challenge for traditional methods of measurement. The most massive galaxies, which should harbour the largest black holes, reside at great cosmic distances from our Milky Way, too far for us to resolve the orbits of their stars. What's more, their black holes are rarely active. A new window into the SMBHs of distant massive galaxies is sorely needed.

My research focuses on gravitational lensing, a phenomenon that occurs when the powerful gravitational field of a massive galaxy curves the very fabric of spacetime, distorting the path of light coming from a remote galaxy situated behind it. This apparent bending of light creates a magnifying effect, akin to using a magnifying glass to enlarge an image. Through the gravitational lens Abell 1201, nature presented me with a unique opportunity: to discover a black hole via gravitational lensing. Unlike other gravitational lenses, a small portion of the light

▲ Supermassive black holes may lie in the centre of virtually all large galaxies, but to find one James Nightingale had to analyse the unseen mass's warping effect inside Abell 1201 (inset)

KEANU2/ISTOCK/GETTY IMAGES, © SMITH, LUCEY & EDGE (2017), NASA/JPL, STSCI, ESO/G.HÜDEPOHL (ATACAMAPHOTO.COM)

THE SKY AT NIGHT WANTS YOUR QUESTIONS

As part of the British Science Festival 2023, *The Sky at Night* is recording a live Q&A programme on 7 September at the University of Exeter. Presenters and special guests will be answering questions from viewers, so if you have a quandry about anything from space travel and technology to astronomy and astrophysics, the team want to hear from you at: **skyatnightqt@bbc.co.uk**

James Nightingale is an observational cosmologist at Durham University, focusing on strong gravitational lensing

from the background galaxy passes tantalisingly close to Abell 1201's central core, within reach of the SMBH's gravity. I undertook a detailed numerical analysis, whereby I simulated millions of different ways for light to have travelled across the Universe and compared them to what was observed in the image of Abell 1201. Only when the bending of light due to its central SMBH was included, in addition to the bending caused by its stars and dark matter, was I able to reproduce what was seen in the data.

The gravitational lensing signal in Abell 1201 is so significant – that is, the path of light has been deflected so much – that an ultramassive black hole approximately 33 billion times the mass of our Sun is responsible. Not only had I discovered the first black hole via gravitational lensing, it turned out to be one of the largest ever found.

I am now searching for gravitational lensing around the most massive known galaxies in the Universe. My hope is that I will find more objects like Abell 1201, that can reveal the mass of their central SMBH. In doing so, I will finally be able to answer the question of how enormous can black holes truly be in the Universe.

As inhabitants of the Universe, the answer to this question will undoubtedly act as a reminder of just how small we really are within the cosmos.

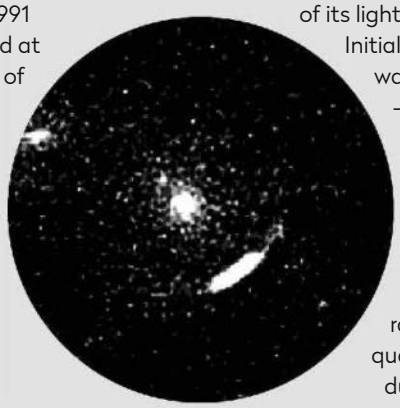
Looking back: The Sky at Night

23 September 1991

In the 23 September 1991 episode, Patrick looked at the exciting discovery of what appeared to be the most luminous object ever seen, that had just been found by the Infrared Astronomical Satellite (IRAS).

During a survey to measure the redshifts of 1,400 galaxies, the team found one, IRAS F10214+4724, appeared to be considerably further away than expected. Its light had set out when the Universe was just 80 per cent its current age and had travelled 16 billion lightyears to reach Earth. At that distance, the galaxy would be brighter than 30 trillion Suns or 30,000 times that of the entire Milky Way.

Yet despite being so luminous it was also practically invisible, as 99 per cent of its light was in the infrared.



▲ **The ultraluminous but largely invisible galaxy discovered in 1991**

Initially, the leading theory was it was a quasar – a galaxy with an extremely bright core due to its central black hole – embedded in a cloud of dust. The ultraviolet and X-ray radiation from the quasar would heat the dust, causing it to glow in the infrared. Such a cloud would have to be enormous though, more massive than all the heavy elements of the Milky Way put together.

Over the next few years, astronomers closely examined the galaxy and soon realised it had been gravitationally lensed, boosting its brightness. However, even once this is accounted for, the galaxy is still classed as 'ultraluminous' and one of the brightest things in the Universe.

The Very Large Telescope

Maggie travels to Chile's Atacama Desert to visit the Very Large Telescope, one of the most advanced optical telescopes in the world. She meets astronomers behind some of the most cutting-edge research, witnesses the incredible engineering behind a major telescope upgrade and discovers what life is like when you live and work in the driest desert on Earth.

BBC Four, **11 September,** 10pm
(first repeat will be on BBC Four, **14 September**, 7pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ **The four optical telescopes that make up the VLT in northern Chile's Atacama Desert**

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Lunar love story

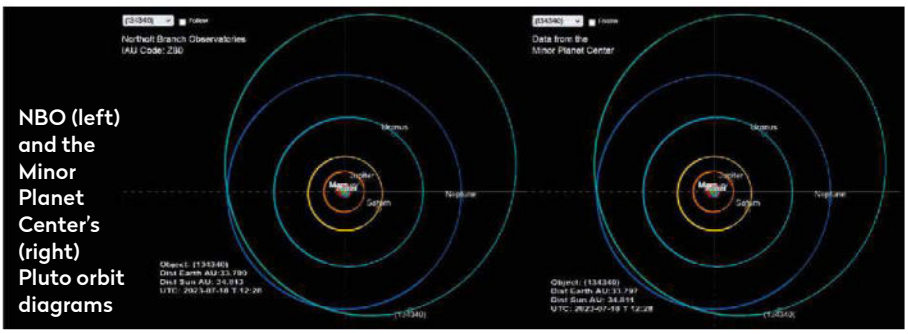
Stuart Hawk's letter in your recent issue ('Libration spotted!', Interactive, July 2023), really struck a chord with me. It described lunar libration and how we see nearer 59 per cent of the Moon's face rather than 50 per cent because of its slightly tilted rotation axis and its slightly non-circular orbit around Earth. Back in 2012, I began photographing the full Moon every month here in North Wales. I still capture the full Moon each month and have missed remarkably few over that time. I use a standard DSLR camera and a telephoto lens set at 300mm, steadied on a suitable surface. Like Stuart, I also use the Mare Crisium to reveal the libration movement from month to month. This isn't a scientific study, rather it's my attempt to record an often-unknown feature of the Moon. Though I've often wondered what other interesting information might be contained in an almost-unbroken, 12-year series of full Moon images.
John Harradine, via email

▲ John has snapped the Moon – and its 'wobble', known as libration – every month for over 10 years

Your dedication to this project is to be applauded, John! If any of our readers have thoughts about how John's images could be used, please email the address above and we'll pass them on. ***– Ed.***

Tweet

Ethan Roberts
@Ethan_Roberts02 • 7 July
Captured the Moon rising behind Redsands fort last night. This sequence of images silhouettes the distant structures and wind turbines. #Astrophotography #moon @skyatnightmag



NBO (left) and the Minor Planet Center's (right) Pluto orbit diagrams

PLUTO ORBITAL DIAGRAMS: CSS/D RANKIN

Pursuing Pluto

I recently read your article about observing the dwarf planet Pluto (Comets and Asteroids, The Sky Guide, July 2023 issue). From the Northolt Branch Observatories (NBO) in west London, we have been keeping tabs on Pluto every year starting from 2017. Using purely our own astrometric measurements from data collected at NBO, we can derive a perfect orbit. We've captured images of Pluto's surface with NBO's 0.25m f/8 Ritchey–Chrétien telescope and QHY42Pro CMOS camera, but thought you'd like to see this pair of orbital diagrams (above) that show a comparison of Pluto orbital elements from NBO (using 33 astrometric measurements spanning seven years) and from the Minor Planet Center (using 9,368 measurements spanning 109 years).
Guy Wells FRAS, Northolt Branch Observatories

Daniel captured this mysterious swirl in the skies over Bora Bora

Spiral stumper

I took this photo (above) with my iPhone, looking east at about 5am from the island of Bora Bora in the South Pacific. Do you have any idea what the spiral shape it shows could be?
Daniel Deangelo, via email

This looks like a rocket stage falling back to Earth. Rockets usually have several stages, each with a separate fuel tank, and they're jettisoned as the fuel runs out. Sometimes the exhaust fumes or extra fuel gets expelled as they fall, creating these spirals in the sky. But it's not possible to verify this since no date was supplied. ***– Ed.***

Number crunch

In your article on the Euclid telescope ('Euclid: Shedding light on the dark Universe', July 2023), you state that visible matter comprises 5 per cent of the total content of the Universe, something I've heard many times. In the same article you say Euclid may reveal huge numbers of brown dwarf stars as well as low-surface-brightness galaxies. If these brown dwarfs etc. aren't visible to current telescopes, but are there anyhow, how can the 5 per cent figure be correct? Surely if these objects are there but we simply cannot see them yet, this would alter the ratio of 'visible' matter to dark matter and dark energy.
John Bigland, Cumbria

The 5 per cent figure is the best that astronomers can arrive at with current observations. It may well change once observations from the Euclid mission can be worked into their analyses. ***– Ed.*** ▶

ON FACEBOOK

We published our list of the 50 greatest astronomers of all time (see bit.ly/famous-astronomers) and asked you for your top picks

Andy Sawers Lots of fun and arguments can be had with this list! Fr Georges Lemaître belongs on it. And while Einstein was no astronomer, has anyone had a greater impact on how we understand the Universe?

Lucas Borkowski It's great to see so many ladies on this list.

Tim Hager Karl Jansky, Subrahmanyan Chandrasekhar, EE Barnard, Henry Draper.

Mick Cassidy The 3rd Earl of Rosse.

Niky Astrea The great Aristarchus! The first one to propose the heliocentric system.

Kevin Nolan Percival Lowell might today be recognised as a pseudo-scientist! Even if you regard him as one, how does he trump Hoyle or the Third Earl of Rosse?

Steve Plenty My dad, who got me into visual astronomy. I'm still going after 40 years – thank you dad.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I'm buying my first new telescope in 10 years and am thinking about a Celestron NexStar 130SLT, but what else could make my life easier, given I have limited spare time?

BEN FRIEL

▲ Scopes like Sky-Watcher's Explorer 130P AZ-GO2 make life a lot easier for beginners

There is a fantastic choice of telescopes and mounts these days and with limited spare time, a simple-to-use but productive instrument makes most sense. A telescope with good light grasp and a moderate focal length, coupled with a Go-To altazimuth mount would be a great choice. The Celestron NexStar 130SLT you are considering hits this sweet spot in many ways: the aperture is a generous 130mm without the telescope being unwieldy, while the 650mm focal length makes it suitable for a wide range of observations covering deep-sky, lunar and planetary objects. The Go-To mount, meanwhile, has a comprehensive feature set, yet is quick to set up and easy to control with the supplied handset.

Another instrument to add to your shortlist would be the Sky-Watcher Explorer 130P AZ-GO2 Wi-Fi parabolic Newtonian telescope. This doesn't have a handset, instead using its own Wi-Fi system to allow control with a smartphone.

Steve's top tip

Why do I need a finderscope?

Trying to locate celestial objects directly through a telescope eyepiece can be quite difficult, as the magnification produced by the telescope only allows you to observe a small portion of the sky at any one time, so it's easy to miss your target. To make the task easier, a small, low-magnification telescope called a finderscope, which has a much wider field of view, can be attached to the main telescope. When the two instruments are aligned accurately with one another, objects found and centred in the finderscope will also be centred in the eyepiece of the main telescope, ready to observe.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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Filter fuddle

I'm a newcomer to astrophotography and use a Canon R6 with either a 24–105mm or 100–500mm lens. In your recent article about solar observing ('Seeing the Sun in white light', July issue), it referred to "white-light solar filters" and also quoted a minimum ND 5.0 filter. I have a ND 10.0 filter. Would this be suitable for imaging?
Chris Hale, via email

Dedicated white-light solar filters for telescopes reduce transmission of harmful wavelengths of the Sun's energy from the infrared through to ultraviolet. We'd recommend using a specialist solar imaging filter in your camera too, as the ND rating on some photographic filters only applies to visual wavelengths. ***– Ed.***

A crescent Mars?

On 18 June I was looking at the night sky with my Swarovski telescope and 120x extender with double eyepiece, and saw what appeared to be a crescent Mars, in the west, at about two-fifths of the way up from the horizon to overhead. With the naked eye it looked like a bright, orange planet or star. I looked numerous times through the scope, seeing the same right-hand crescent shape, but I couldn't find any evidence of this phenomenon online. What could I have seen?
Ella Schierbeek, via email

As Mars orbits the Sun outside Earth's orbit, it never appears as a crescent when viewed from Earth. We'd suggest the crescent you saw was Venus, which was in the same region of sky as Mars on 18 June and would have appeared as a thick crescent, and also orange in colour when low to the horizon. ***– Ed.***

Instagram

astrofarnell • 17 July

My image of the Sun today. Captured on 17 July 2023 at 15:43pm GMT. Using a Sky-Watcher Explorer 130P 650mm with solar filter on the EQ2 mount. ZWO ASI294MC Pro camera. ASIStudio for image capture and image stacking, and Photoshop @bbcskyatnightmag

CORRECTIONS

In our August issue, in 'The Big Three' (page 46), "Looking northwest towards Perseus" should have read "Looking northeast". In the feature 'The Great American Eclipses' (page 40), the annular eclipse will move southeast from Oregon not southwest as stated.

SOCIETY IN FOCUS

Mid-Kent Astronomical Society (MKAS) was formed in 1976 and has grown over 47 years into a strong group with over 100 active members of all ages and levels of knowledge, even while retaining some of the founder and early members.

At MKAS we pride ourselves on the friendliness of our club and this, coupled with members' eagerness to help others, is a remarkable indication of the depth of knowledge within our society. Meeting twice monthly, we host many impressive speakers throughout the year and are repeatedly entertained with fabulous presentations. Our venue near Gillingham in Kent affords dark skies that permit observing sessions later in the evenings. We organise regular observing events and our annual presence at the Kent County Show is always well received.

▲ MKAS members demonstrate telescopes at one of their popular outreach events

Last year we hosted over 140 visitors at our ever-popular and highly successful annual 'Family Space Night', aimed at inspiring youngsters (and their parents) in the wonders of space and science. The future is very exciting, with plans to permanently house our large 20-inch telescope and the re-opening of our observatory in Canterbury.
Dave Merrall, Press Secretary, MKAS
▶ www.midkentastro.org.uk

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Capturing the Visible Universe in a Single Image

Astronomical Society of Edinburgh, online, 15 September, 7:30pm

US astrophotographer and author Charlie Bracken and former BBC producer Max Whitby spent two years creating a single image that shows the entire celestial sphere in both RGB colour and hydrogen-alpha. Find out how they did it in this free, livestreamed talk.

www.youtube.com/@AstronomicalSocietyofEdinburgh

The Changing Climate of Mars

St James the Less Church Hall, Maidenhead, 1 September, 7:30pm

University of Oxford planetary physicist Peter Read will discuss changes in the Red Planet's atmosphere, weather and climate over the millennia. Free for Maidenhead Astronomical Society members, non-members £2.

www.maidenhead-astro.net

Stellar Evolution

Kindle Centre, Belmont Road, Hereford, 1 September, 7pm

Former BAA president Roger Pickard visits Herefordshire Astronomical Society to discuss the birth, life and death of higher-mass stars. £3, visitors welcome.

sites.google.com/site/hsastro/home

The Right Light at Night

Bath Royal Literary & Scientific Institution, Queen Square, Bath and via Zoom, 8 September, 7:30pm

Subtitled 'Its effects on the planet and how to tackle it', this is the first of four 'Conserving the Planet' lectures presented by the William Herschel Society and the Herschel Museum of Astronomy this autumn. Admission £6 (£3 concessions).

herschelsociety.org.uk

Wonders of our Universe

Nazarene Theological College, West Didsbury, Manchester, 11 September, 7pm

BBC Sky at Night Magazine's own Paul Money takes you on a tour of what lies beyond the Solar System – both within the Milky Way and all the way out to the furthest reaches of the Universe. Free for West Didsbury Astronomical Society members, visitors welcome.

wp2019.wdas2.com/wp2019

Last Horizons: The Edge of the Solar System

Larmour Theatre, Queen's University Belfast, 21 September, 7:30pm

What lies beyond Pluto? Is there a Planet Nine out there? The question of where our Solar System really ends is up for discussion once more. Dr Steph Merritt of Queen's University Belfast explains all. Non-members welcome. **irishastro.org**

PICK OF THE MONTH

▲ **The packed weekend promises family workshops, solar observing, talks and quizzes**

Herstmonceux Astronomy Festival

The Observatory Science Centre, Herstmonceux, Hailsham, 1–3 September

This annual festival returns to the site of the old Royal Observatory to welcome the start of a new season of longer nights. The weekend-long festival is aimed at seasoned astronomers and families alike. Expect astronomy talks, including a food-based guide to cosmology with Professor Kathy Romer and an audience with *The Sky at Night*'s Chris Lintott (both pictured above), observing through telescopes (weather permitting), planetarium shows, solar observing, historic telescope demos and a pub quiz! Weekend tickets are £54 per adult and £42 per child. Day tickets are £13.50 per adult and £10.50 per child, with discounts for family tickets available. For more details, visit **www.the-observatory.org/events**.

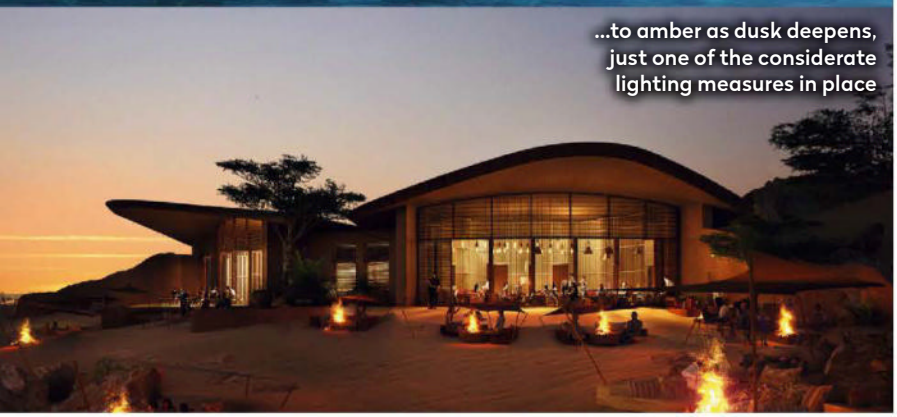
CHARLES BRACKEN/MAX WHITBY, THE OBSERVATORY SCIENCE CENTRE X 4

FIELD OF VIEW

When it comes to lighting, less is more

Patricia Yanez on designing considerate lighting for a luxury Red Sea resort

The Red Sea resort's lighting can be changed from yellow colour temperatures...



...to amber as dusk deepens, just one of the considerate lighting measures in place

Dr Patricia Myriam Yanez is director of lighting design at Red Sea Global, the company behind The Red Sea resort, set to welcome its first guests in late 2023

As the director of lighting design at The Red Sea project I've been leading a team to put together a unique set of guidelines to keep our night skies pristine. We're building a luxury tourism destination and developing a number of hotels along the Red Sea coast in Saudi Arabia, as one of the country's Giga Projects. Right from the start of the project, we've set out to minimise light pollution as part of a wider set of environmental preservation measures.

Environmental sustainability is a core focus for us as a hotel. Last year we completed the baseline measurements for a full sky quality survey, taking readings in a giant grid from the wider 28,000-square-kilometre area the hotels sit in. This contains dormant volcanoes, desert dunes, mountain canyons and 200 kilometres of coastline that includes an archipelago of 90 islands surrounded by the world's fourth-largest barrier reef system. The readings from this demonstrate the exceptional quality and darkness of the skies, measurements that position us as eligible to be one of the largest areas in the world with dark-sky certification.

We intend to keep it that way with the dark-sky guidelines we have developed based on standards set by the International Dark-Sky Association (IDA). The IDA doesn't certify our kind of development at the moment, but the guidelines allow us to meet them and also the needs of the hospitality industry. We firmly believe in the principle of less is more. By employing minimal lighting we can preserve the natural beauty of the night sky. So, for example, that means using colour temperatures up to 2,700 Kelvin in exterior lighting, and 2,200 Kelvin amber lighting in internal areas.

Our lighting fixtures also have guidelines so that all light sources are carefully selected and very well directed, with shields and cowls that block the spread of light and prevent light pollution, while the beam angle must not spread light where it doesn't need to. The guidelines also have an emphasis on cutting out glare, since light shining directly into the eyes while stargazing can ruin the experience. That means fitting light sources with shields, honeycomb louvres, diffusers – accessories that can guarantee visual comfort. Smart lighting controls also help here, giving us flexibility to control the brightness of lighting at different times.

At the moment there isn't a set of industry benchmarks for lighting, but I am ambitious for The Red Sea to change that with these new standards. Already we're applying our lighting guidelines at other resorts we're developing, such as Amaala, another Giga Project here in Saudi Arabia. We are working with around 80 lighting consultancies all over the world, who all have the guidance. So I hope the application of good lighting standards will become a natural part of conversations and developments elsewhere. We're seeing the cities on the Red Sea near the resort looking at our recommendations on improving lighting, and it's great to see our work being shared and spread.

RED SEA GLOBAL X2

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BBC
Sky at Night
MAGAZINE

Welcome back, dark skies! Whether it's the beautiful seasonal constellations rolling into view or eclipses, occultations and meteor showers, we tell you what lies in store this autumn

Highlights of the autumn skies

From returning favourites to unmissable one-off events, **Katrin Raynor** picks out the best night-sky sights coming up in the months ahead

As September approaches, astronomers leave the long, hazy days and short, bright nights of summer behind and welcome the return of dark skies. The longer, darker nights allow us to view some of the most loved and prized night-sky objects that return each autumn.

And there's a lot to look forward to this season, whether you're using your naked eye, binoculars or a telescope. This guide will help you find some fascinating objects, either from your garden or from a dark-sky site away from light pollution, whether you're an absolute beginner or a more well-seasoned astronomer. Remember to wrap up warm and grab a red torch to follow this guide as you head out into the dark. Downloading a stargazing app will help you find your way around the targets we highlight too.

Katrin Raynor is an astronomy writer and a fellow of the Royal Astronomical Society

September

After midnight on 4 September, **Jupiter** will be shining close to a waning Moon low in the eastern sky. Just over a week later, on 12 September, a very thin waning crescent **Moon** and **Venus** will create a spectacular sight just before dawn. At 6:50am on 23 September, the **autumn equinox** occurs – the point at which the Sun illuminates the Northern and Southern Hemispheres equally, marking the start of autumn in the Northern Hemisphere. After sunset on 29 September, look to the east to see the last **supermoon** of the year rise above the horizon, when it will appear bigger and brighter than usual.

▲ There's a supermoon on 29 September, when the full Moon will appear brighter and larger than average

Now's the time to catch the must-see Andromeda Galaxy, visible to the naked eye under dark skies

Comet 103P/Hartley should become visible as it makes its 6.4-yearly visit this autumn

During September, **comet 103P/Hartley** could become a viable target to track for sky-watchers with binoculars and small telescopes.

Constellations of the month include **Andromeda** and **Cassiopeia**. They lie close to each other and are visible after 10pm towards the northeast. Use Cassiopeia, the distinctive W-shaped constellation, to star-hop to Andromeda. The brightest stars in Andromeda are Alpheratz (Alpha Andromedae), Mirach and Almach.

Within Andromeda is one of the most famous deep-sky objects of all, the **Andromeda Galaxy**, M31. Located 2.5 million lightyears away, the spiral galaxy is the most distant object we can see with the naked eye, looking like a smudge of light. Using a small pair of binoculars (10x50) will bring out its central region and will make it appear brighter too. The star Schedar in Cassiopeia will point the way to it. ▶

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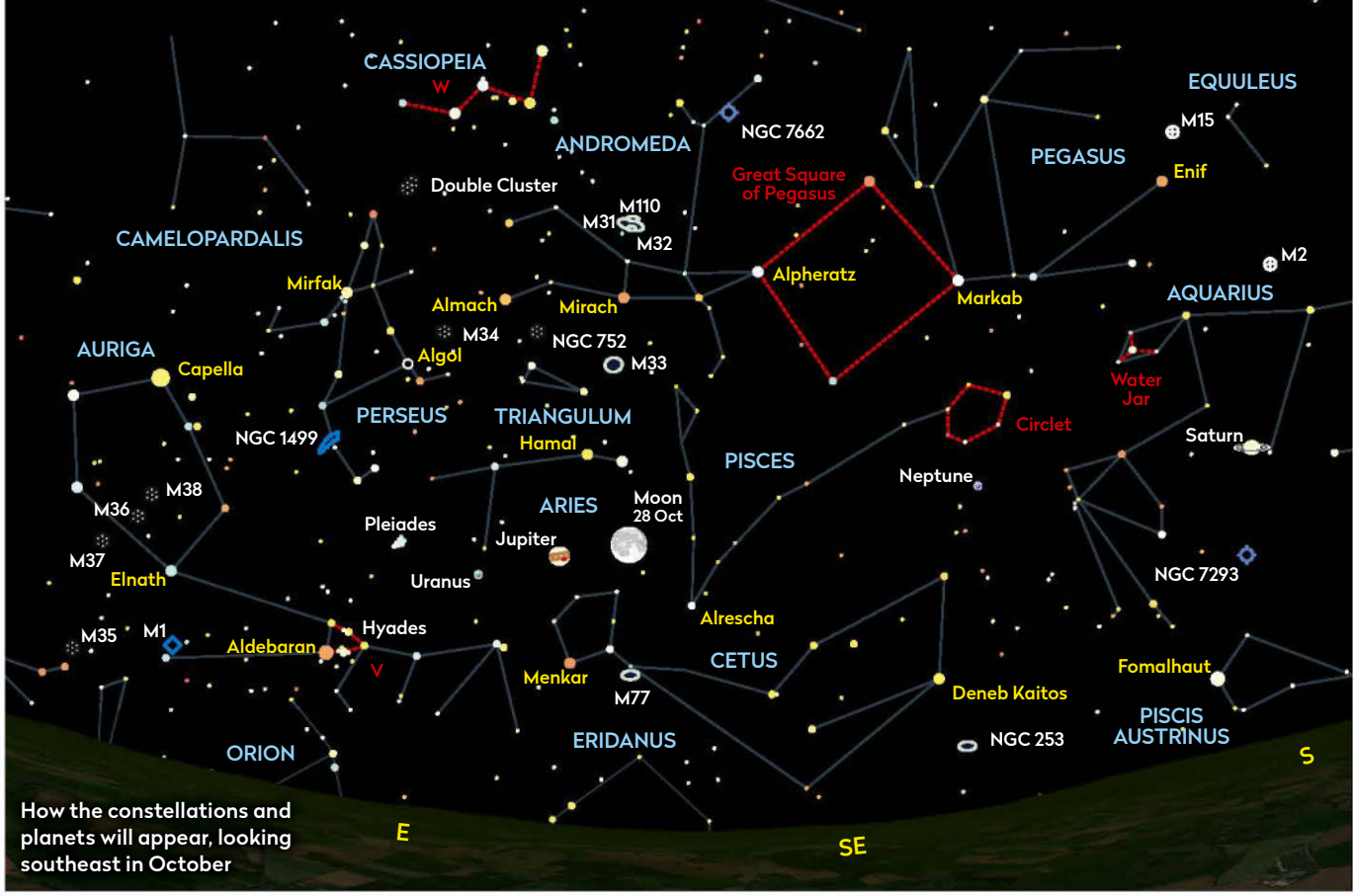


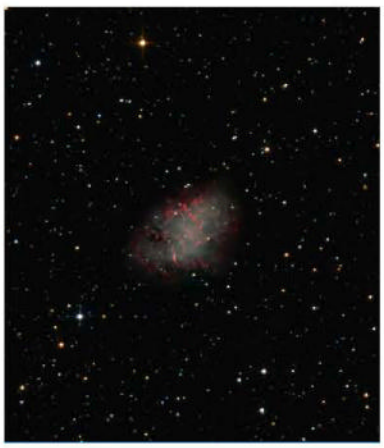
How the constellations and planets will appear, looking southeast in October

HANNES SCHACHTNER/CCDGUIDE.COM, STGRAFIX/ISTOCK/GETTY IMAGES, MARKUS BLAUENSTEINER + CEDIC TEAM/CCDGUIDE.COM, KONSTANTIN VON POSCHINGER/CCDGUIDE.COM, CLAUDIODIVIZIA/ISTOCK/GETTY IMAGES, CHARTS BY PETE LAWRENCE

October

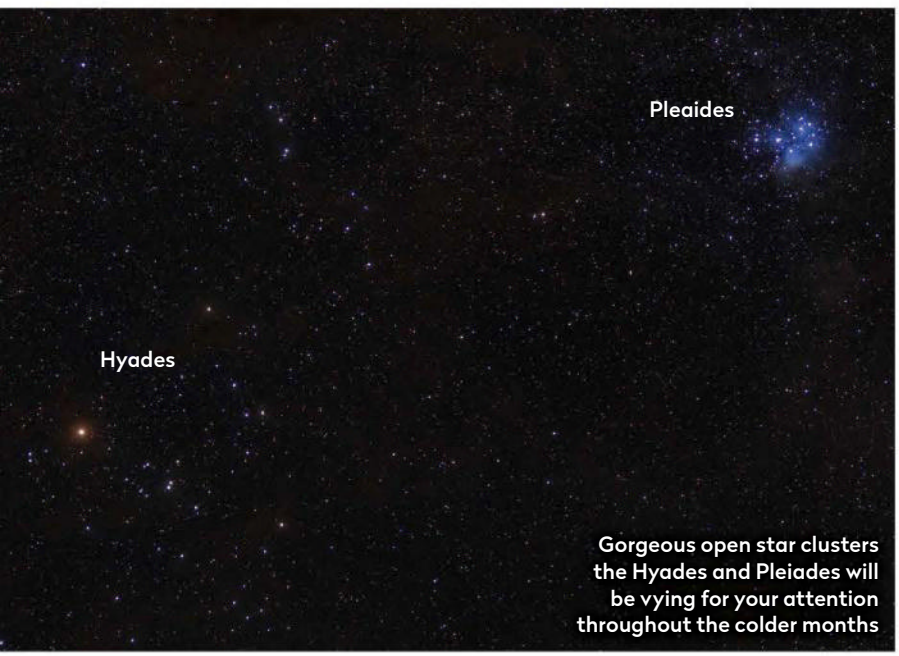
The large, sprawling constellation of **Taurus**, the Bull is a great target this month, best viewed from mid-October. It is dominated by **Aldebaran**, an unmistakable glowing orange star that forms the eye of the bull. This beautiful jewel of a star can be used to star-hop to the famous **Crab Nebula**, M1. Too faint to be visible with the naked eye, larger telescopes with 50x magnification will bring this nebula to life as a hazy patch of gas and dust through the eyepiece.

Taurus also hosts two fantastic naked-eye open star clusters. Aldebaran is surrounded by one of these star clusters, a striking V-shaped pattern of stars lying on its side, called the **Hyades**. Just above this is another open star cluster called the **Pleaides**, commonly known as the Seven Sisters because of the seven stars you can see with your naked eye, although it contains many more than that.



▲ The ghostly supernova remnant Crab Nebula is a big-aperture treat

▲ A partial eclipse on 28 October will take a bite out of the Moon



Gorgeous open star clusters the Hyades and Pleiades will be vying for your attention throughout the colder months

Venus and **Jupiter** are still present in the morning and evening sky respectively throughout October. **Saturn**, **Neptune** and **Uranus** are also on view. Look to the east after 10pm to locate the Pleiades and Jupiter. Uranus lies between them and is best viewed through binoculars or a telescope, which will show its tiny green disc. In the south, the ringed planet Saturn shines at around magnitude +0.6, easily visible to the naked eye, while hard-to-spot Neptune, a telescope target, lies between Jupiter and Saturn.

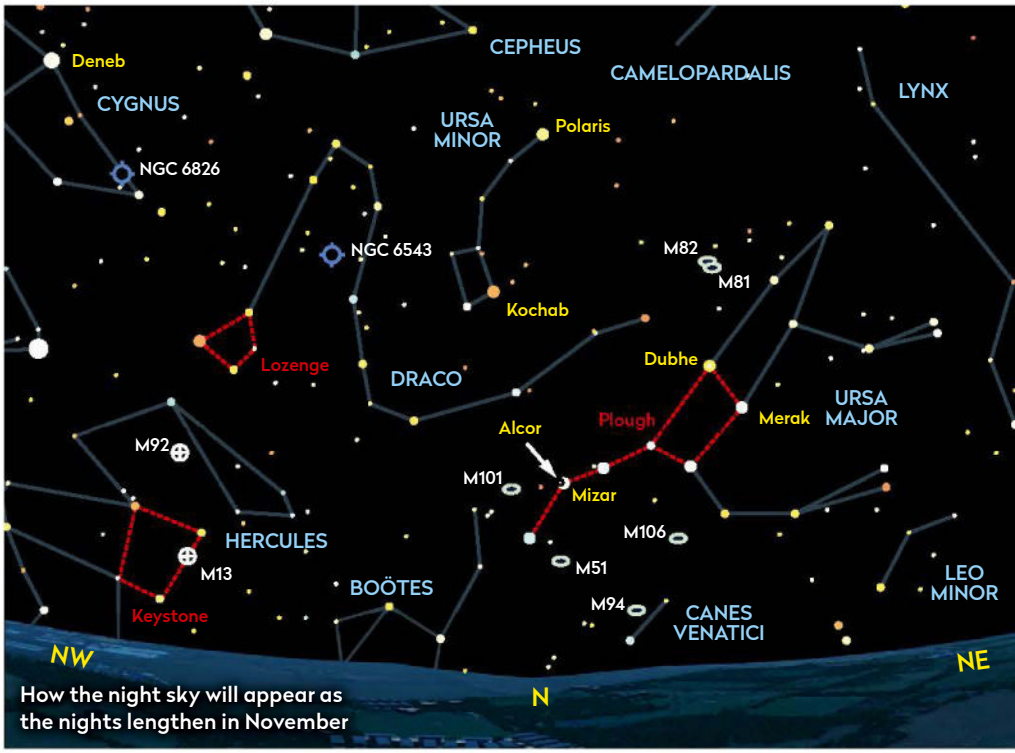
The UK and Ireland will enjoy an autumnal **partial lunar eclipse** on the evening of 28 October between 20:35pm and 21:53pm, when 12 per cent of the Moon's surface will be darkened by the shadow of the Earth. The southern area of the Moon will appear dark and faintly reddish in colour as it passes through Earth's umbral shadow. A perfect photo opportunity!

▲ Catch a rare day-time lunar occultation of Venus on 9 November. The bright planet will appear 1/90th the apparent size of the Moon

November

At the beginning of the month, Jupiter reaches its closest point to Earth and on 9 November, we are treated to a **lunar occultation of Venus**, when the bright planet will pass behind a day-time Moon at approximately 9:45–10:45am. On 13 November, **Uranus** makes its closest approach to us. Located in the east between Jupiter and the Pleiades, this distant ice giant world will be a naked-eye object from dark-sky areas, but a telescope should show it as a 'star' with a subtle greenish hue.

The constellation **Draco**, the Dragon winds its way between Ursa Major, the Great Bear, and Ursa Minor, the Little Bear. Visible in the sky all year round, these constellations hold some delightful targets. The Big Dipper or **the Plough** is an asterism – a pattern of stars within a constellation – that forms the back and ▶



How the night sky will appear as the nights lengthen in November

Planets you'll see this autumn

Several of our Solar System neighbours get their time to shine

The planets put on a captivating show throughout autumn, all easily viewed with the naked eye or optical aids. At points during each planet's orbit, Earth is positioned between them and the Sun. When this happens, the planet is said to be at **opposition**. There are also times during a planet's orbit where it may be obscured from view by another object in the sky. This is called an **occultation**. A lunar occultation occurs when the Moon obscures an object from view. Each planet's orbit varies. The inferior planets, Mercury and Venus, orbit very close to the Sun compared to the outer planets. This can make viewing Mercury especially tricky, but during periods of greatest **elongation**, when these planets are furthest from the Sun in their orbit, we get a chance to see them in the sky before sunrise or after sunset. From September to December, we have numerous chances of observing the planets in one of these three positions.

▲ Catch Jupiter and its major moons when the planet reaches opposition on 3 November

On 19 September, **Neptune** is at its closest point to Earth and at opposition, but will be too faint to see with the naked eye. **Mercury** is at its greatest elongation from the Sun on 22 September and can be seen in the dawn sky after 5am. **Jupiter** is at opposition on 3 November and will increase in brightness throughout the month. Watch the daylight lunar occultation of bright **Venus** sailing behind our nearest celestial neighbour at 9:45am on 9 November and four days later, **Uranus** is at opposition.

▲ **Opposition on 13 November is a good time to spot Uranus's distinctive green hue**

▶ tail of Ursa Major. **Mizar** and **Alcor**, a double star in the handle of the Plough can be seen with the naked eye: Mizar is the brightest of the two, so reach for your binoculars or small telescope if you are struggling to see the dimmer Alcor. Also within Ursa Major lie deep-sky objects **Bode's Galaxy**, M81 and the **Cigar Galaxy**, M82. Larger telescopes will bring out the spiral structure of Bode's Galaxy and the rod shape of the Cigar Galaxy.

A **full Moon** will shine brightly in the night sky on 27 November rising in the east after 4pm, washing out any fainter stars or deep-sky objects. Nevertheless, the Moon is a great target for beginners who want to get to know their way around our nearest celestial neighbour. A pair of binoculars will show craters and seas at full Moon, and more detail at other phases.

▲ **The strikingly contrasting Bode's Galaxy, M81 and Cigar Galaxy, M82 in Ursa Major are a favourite duo for astro imagers. Large apertures will reveal their spiral and rod shape**

BERNHARD HUBL/CCDGUIDE.COM, HORST ZIEGLER/CCDGUIDE.COM, DAVIDHOFFMANNPHOTOGRAPHY/ISTOCK/GETTY IMAGES, CHRISTOPH KALTSEIS/CCDGUIDE.COM, KURGUZOVA/ISTOCK/GETTY IMAGES, CHART BY PETE LAWRENCE

Autumn's comets and meteors

Lots of meteor showers will pepper the skies in the coming months

There are no bright, naked-eye comets on the horizon, but **103P/Hartley** – a short-period comet that rounds the Sun every 6.4 years – could be favourable in September. It will be visible in the late evening/early morning sky as a seventh-magnitude object, drifting through Perseus and into Auriga, passing Capella before dropping down into Gemini. Too faint to see with the naked eye, it should be an easy target for binoculars and small telescopes. Its maximum brightness coincides with the presence of a big, bright Moon, which will affect its appearance, but it will still be worth a look.

Although the lack of bright comets is disappointing, there are plenty of meteor showers to enjoy with minimal interference from the Moon:

DRACONIDS: peaking on 8–9 October, expect to see meteors at a rate of around 10 per hour. Look towards the constellation Draco for the radiant.

We kick off with two meteor showers reaching their peak in October

ORIONIDS: peaking on 21–22 October, the radiant is within the constellation of Orion, rising in the east after 10pm. Expect to see around 25 per hour.

TAURIDS: also known as the Halloween Fireballs, they are visible from the end of October to the beginning of December, originating from Taurus, peaking on 12–13 November.

LEONIDS: peaking on 17–18 November, this shower could produce some fireballs, streaking out of the constellation of Leo.

GEMINIDS: a really impressive show of meteors that peaks on 14–15 December, producing around 150 meteors an hour originating from Gemini. The peak occurs during a new Moon this year, promising excellent views.

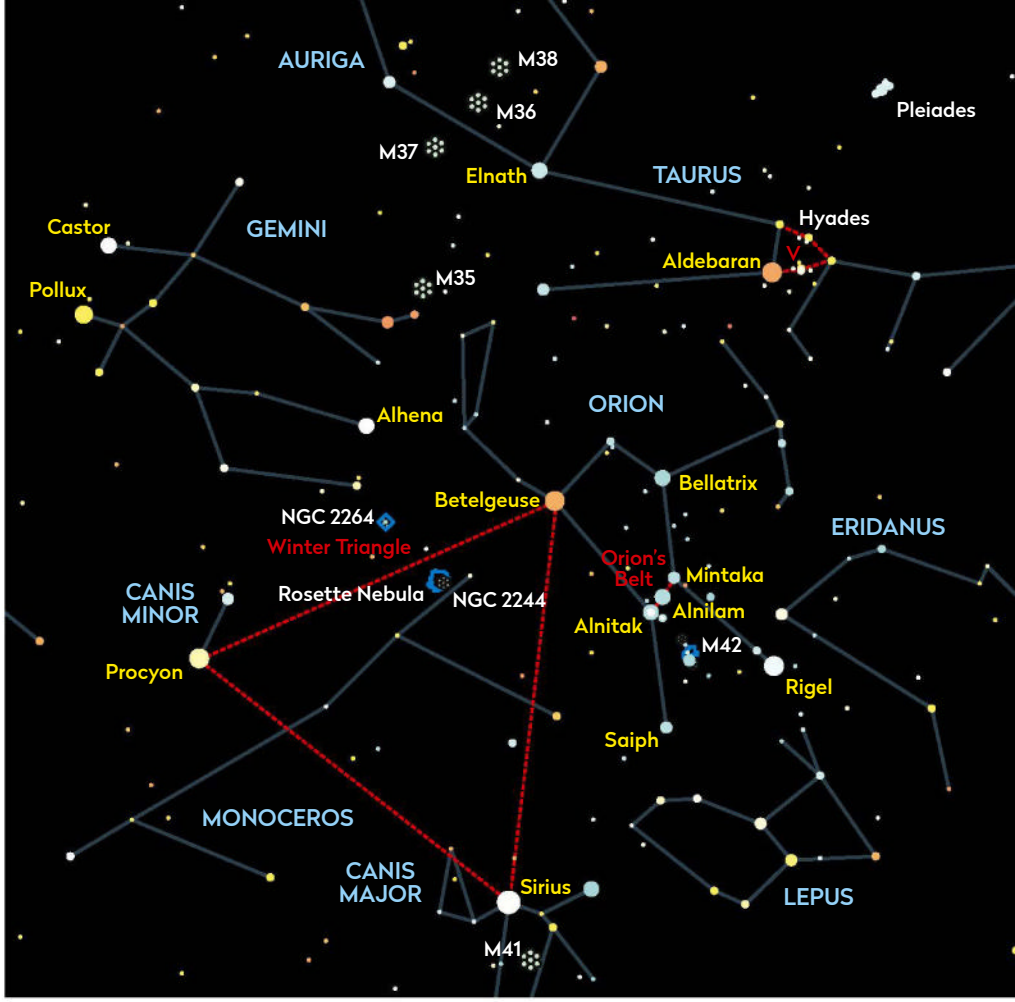
URSIDS: ending the year, the Ursids meteor shower is sparse and coincides with a full Moon. Peaking on 22–23 December, expect to see only around 10 an hour originating from Ursa Minor.

December

A dazzling **Venus** and a waning crescent **Moon**, two of the brightest objects in the sky, treat us to a magical pairing before dawn on 9 December.

As we approach mid-winter, the stunning constellation of **Orion**, the Hunter is prominent. It can be found rising in the east after sunset and is easy to identify from the three stars aligned in an almost straight line across its centre. These three stars – Alnitak, Alnilam and Mintaka – form the famous asterism **Orion's Belt**. Orion is a favourite with many sky-watchers, not only because of its two brightest stars – **Betelgeuse**, a bright orange star and **Rigel**, a cooler blue supergiant – but because it contains one of the most beautiful deep-sky objects in the whole sky.

The **Orion Nebula**, M42 is located in the centre of **Orion's Sword**, a shorter vertical line of three fainter stars which hangs down from Orion's Belt. The nebula looks like the middle 'star' of the sword to the naked eye, but a little bit fuzzier than the stars above and below it. Even a small pair of 10x50 binoculars will bring out this stellar nursery's grey-green nebulosity.

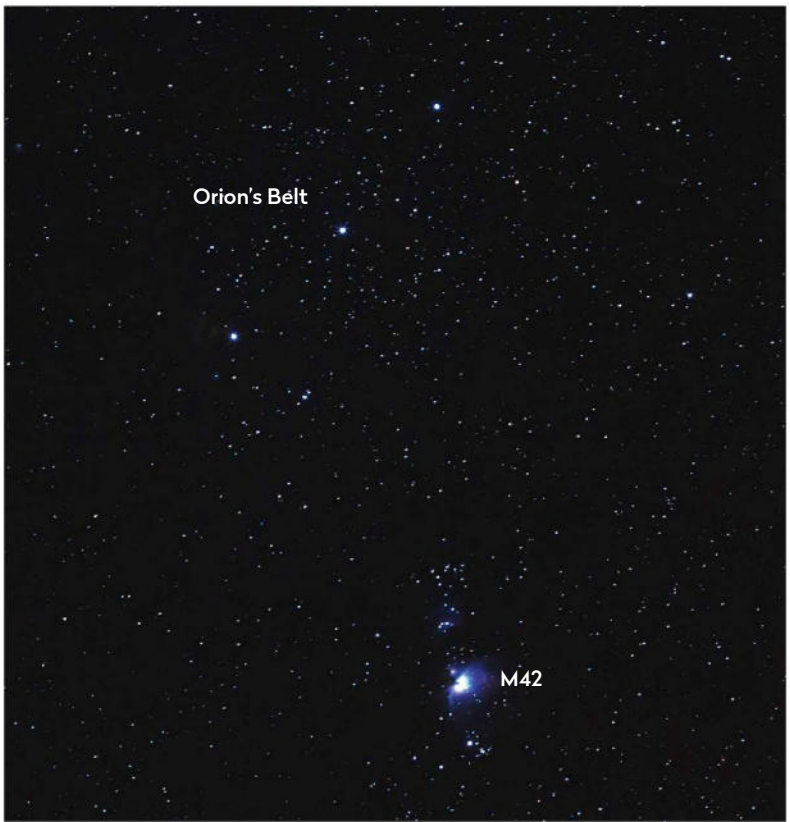


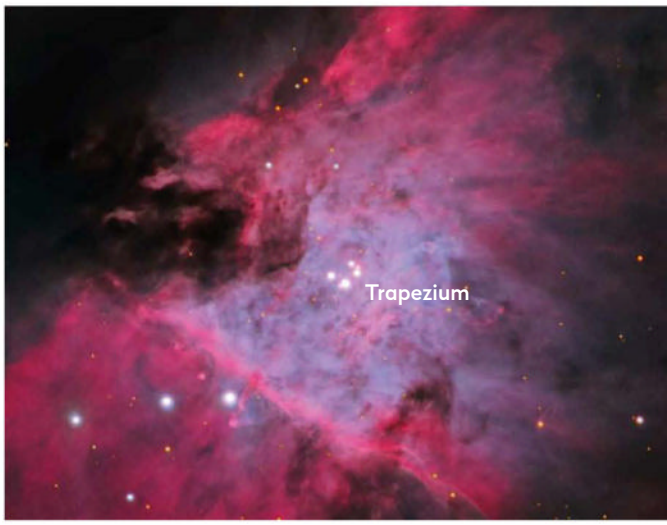
▲ **December holds many treats for stargazers as the longest, darkest nights finally arrive, from crisp views of winter favourite Orion to a very promising Geminids display**

A tight cluster of four stars called the **Trapezium** glows within the heart of the Orion Nebula, and can be easily seen through a small telescope.

The constellation of **Gemini**, the Twins can be found above Orion's left shoulder. At this time of year, the twins appear to be lying down with their feet near Orion's raised arm. Gemini's two most prominent stars, **Castor** and **Pollux**, form the heads of the twins and can be found by drawing an imaginary line through Rigel to Betelgeuse. Extending this line will lead you neatly to Castor and Pollux, positioned one above the other.

On 21 December, we celebrate the **winter solstice**, when Earth's northern pole is at its maximum tilt away from the Sun and our star will be at its lowest daily maximum elevation in the sky.





▲ **Buried within the famous Orion Nebula, M42, is the magnificent glowing Trapezium Cluster**

◀ **Dangling below Orion's iconic Belt, the fuzzy glow of the Orion Nebula, M42, is a delight in binoculars and a perfect first target if you're starting astrophotography**

10 targets *to get you started in* astrophotography

From star trails to your first planets, **Tom Kerss** shares 10 inspiring projects to kick off your night photography journey

Tom Kerss is an astronomer and writer. His second children's picture book, *The Squirrel that Found the North Star*, is out now

There's a long-standing debate among amateur astronomers: which is better, observing the sky with your eyes or capturing it with your camera? It will always be a matter of personal taste, but the good news is that for anyone looking to try their hand at astrophotography, there's never been a better time. Whether it's taking casual snaps of the stars or delving into more advanced techniques – what the seasoned called 'imaging' – this hobby has seen an explosion of popularity. Increasingly ubiquitous astro-capable cameras and superb software have made astrophotography easier. Want to try it? Here are 10 targets to get you started. ▶

BOJANSTORY/ISTOCK/GETTY IMAGES

We bring you the tips, techniques and kit you'll need to take your first steps into night-sky photography

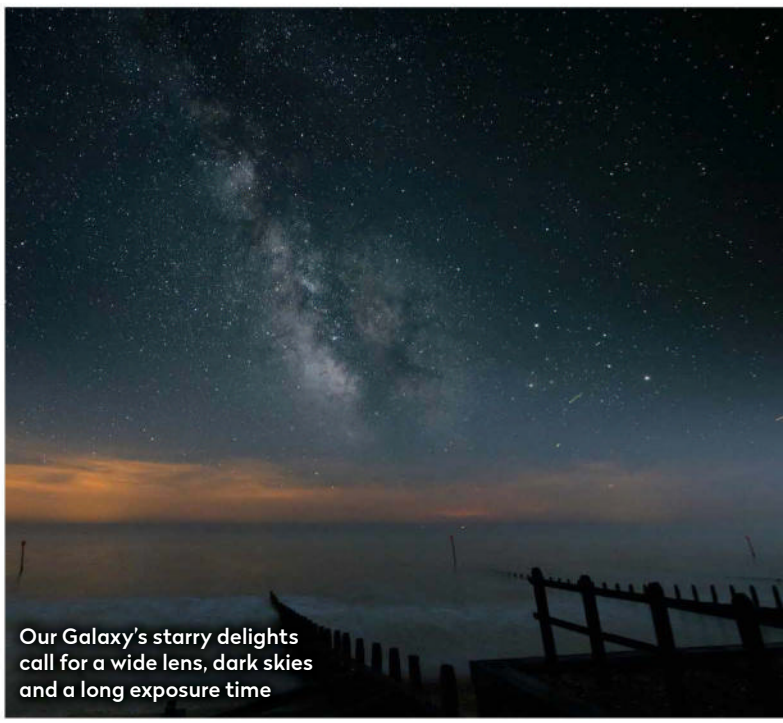
Start simple

Nothing is easier than placing your camera or smartphone on a tripod and shooting away, as you'll find with these entry-level projects

1. The Milky Way

Capture the river of light that crosses the sky

The warm nights of summer and the early autumn invite us to stay out and enjoy the splendour of the Milky Way. Rich with the light of billions of stars, it's a perfect playground for experimenting with your camera. Investigate your lenses and choose a wide one with a fast maximum aperture, such as f/1.4, f/2.8 or f/4. Angling your camera up to the sky, you should be able to see various brighter stars on its live view screen. This will aid with manually focusing and with framing the Milky Way's bright core. With an ISO value of 800 or 1600, take exposures of 5–15 seconds. Star trailing will become evident on longer exposures, but use the '500 rule' to avoid the shot being spoiled. This states that your maximum exposure (in seconds) should be no more than 500 divided by your lens focal length in millimetres. For example, with a 14mm lens don't go longer than 500 ÷ 14 = 36 seconds. If your camera has a crop factor (see your user manual), multiply the focal length by that first. So for a 14mm lens on a DSLR with a 1.6x crop factor, the maximum exposure time becomes 500 ÷ (14 x 1.6) = 22 seconds.



Our Galaxy's starry delights call for a wide lens, dark skies and a long exposure time

2. Meteors

Catching shooting stars is mostly down to serendipity, but you can give luck a helping hand

Taking lots of shots at regular intervals will help you nab a meteor

When shooting the night sky, it's not uncommon to capture a streak of light. Usually this is a satellite trail, but rarely you'll encounter a natural streak – a meteor! It's mainly down to chance, but you can greatly increase your odds by shooting during a meteor shower and by taking a continuous sequence of exposures. Using an intervalometer, or timelapse remote, you can set your camera going and enjoy the shower with your own eyes. Later, skim through your images and see what you get. Bright meteors, such as fireballs, will be hard to miss and often produce varicoloured trails as they travel through the atmosphere. Your camera may have onboard noise reduction enabled – switching this off will minimise the gaps between exposures. Of course, if like me you're often terribly unlucky, you might not catch any meteors, but your sequence of identical images can still be put to good use for creating star trails.

3. Star trails

The arcs of passing stars are a great way to show the motion of Earth on its axis

Whenever you try to shoot a meteor shower, you'll end up with perhaps hundreds of identically positioned photographs, evenly spaced in time. These are ideal collections from which to create star trail images. Such beautiful works of art illustrate the rotation of Earth and, as each star in the sky traces its arc around the celestial pole, the effect becomes more dramatic when facing north. Star trails also look fantastic in contrast with a perfectly still foreground, such as a building or rock feature. There are two excellent, easy-to-use pieces of free software that turn your sequences into trails: StarStaX by Markus Enzweiler, which is available for macOS and Windows (**markus-enzweiler.de/software/starstax**), and Sequator by Yi-Ruei Wu, which is available for Windows (**sites.google.com/view/sequator**).

Merge your photos to get a spectacular image showing Earth's rotation

ALL PICTURES: TOM KERSS

▲ A Moon that's low to the horizon can make a superb, but challenging, subject

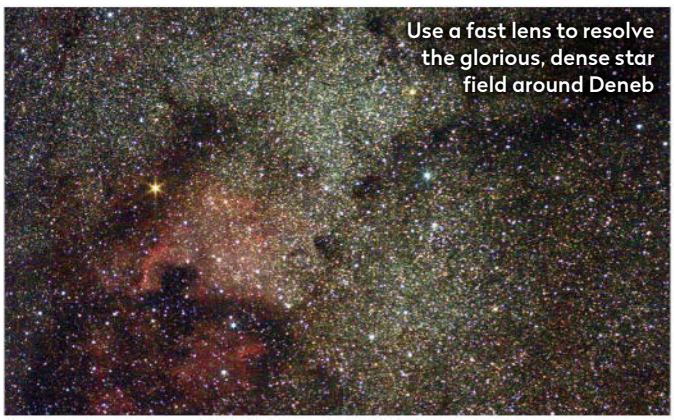
4. Two worlds together

Shooting both the Moon and Earth requires a little balance

Of course, our celestial companion makes a gorgeous subject for photography. The Moon is probably the easiest target in the sky – conspicuous and ever-changing, it offers many avenues for creativity. When the Moon is relatively low on the horizon, you can capture two worlds in one photo. Here you'll discover that the Moon appears very small through wide-angle lenses; consider using your longest lens to see how much detail you can tease out. The Moon shines in very bright contrast against a dark sky, which makes it challenging to frame among the stars. Underexposed shots will show the Moon's surface features but fail to bring out stars, whereas overexposed shots will recover stars at the expense of blowing out the Moon. An exception is possible during a fine crescent phase, where long exposures can simultaneously reveal stars as well as the Moon's faint night side, which is itself illuminated by the brightness of Earth.

Going deeper

A tracking device is an essential upgrade for astrophotography, allowing long exposures and longer lenses to bring out fainter details



Use a fast lens to resolve the glorious, dense star field around Deneb

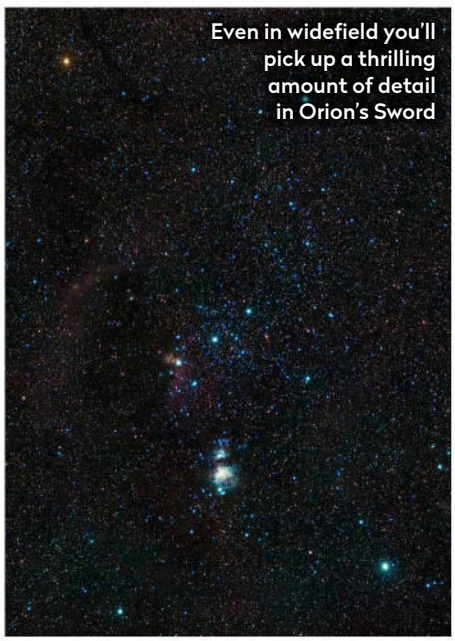
5. Star clouds in Cygnus

You can bring out even more detail by stacking together multiple images

The brightest region of the Milky Way is its core, but that only skirts our southern horizon; to us, the star clouds of Cygnus are more prominent. Gazing at the northeast of the Summer Triangle, you'll find yourself looking along the spiral arm we inhabit in the Galaxy. A rich concentration of distant light paints the scene around the brilliant star Deneb. On a tracking mount, use a fast telephoto lens to resolve the many stars. This subject provides a good opportunity to try aligning and stacking multiple exposures to reduce noise in your image. Try free tools such as Siril (macOS, Windows, Linux; **free-astro.org/index.php/Siril**) and DeepSkyStacker (Windows, **deepskystacker.free.fr**). Even if you're new to stacking, it's worth taking lots of images of each deep-sky target, as you'll be able to return to the data later on and produce better results with the benefit of your experience.

6. Jewels of Orion

The familiar constellation boasts a host of fascinating deep-sky objects



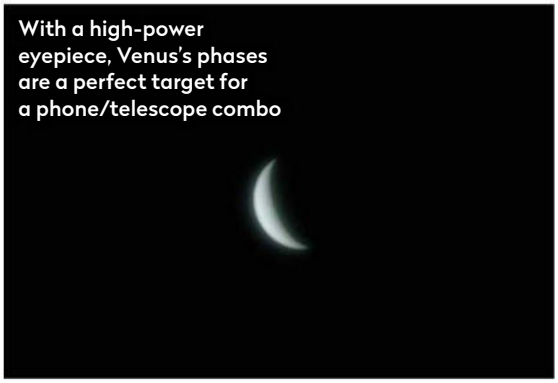
Even in widefield you'll pick up a thrilling amount of detail in Orion's Sword

The mighty Orion will be upon us soon as the autumn rolls around. A splendid tapestry of colourful stars and nebulous features, this constellation is home to a chain of objects called Orion's Sword. Among them is the Great Nebula in Orion (M42), which is conspicuous in photographs. Using a lens with a focal length of 50–70mm, you can generally frame the most interest parts of the constellation fully, while also resolving some of the details that make the Sword so special. You may be surprised to see the iconic Horsehead Nebula (Barnard 33) clearly visible in your images. Orion's dramatic colours can be drawn out by stacking images, and correctly calibrated in tools like AstroPixelProcessor (macOS, Windows, Linux; **www.astropixelprocessor.com**). ▶

Snaps through the eyepiece

With a special adaptor, you can use your smartphone to snap quick shots through your telescope eyepiece

Modern smartphones can produce excellent night-sky pictures



With a high-power eyepiece, Venus's phases are a perfect target for a phone/telescope combo

7. The disc of Venus

Smartphones offer a quick, easy way to capture our closest planet's phases

Our nearest neighbouring planet, Venus, is a treat through a telescope. As Galileo first discovered over four centuries ago, it shows changing phases as it orbits the Sun. Among the planets, it can produce the largest and brightest disc as seen from Earth, and it's an ideal target for smartphone astrophotography practice. Use a high-power eyepiece (at least 50x magnification) and ensure your telescope is focused by eye, then swap to your smartphone. Your camera's autofocus may not produce good results, and it may also struggle to expose correctly for the high contrast of the scene. Consider using manual settings to control the exposure and focus. You may need to source an app to enable this. You should also shoot in your phone's raw image format where possible. Naturally, touching the phone will cause the telescope to wobble, so use a countdown timer, Bluetooth remote or – if your phone supports it – voice-activated shutter.

8. Jupiter and the Galilean moons

Capture the movement of the four moons around the gas giant

While Venus is essentially featureless in appearance (unless we use special filters and cameras), the Solar System's largest planet, Jupiter, has a very interesting face. Your phone's camera, correctly exposed, can reveal its various cloud belts, and larger storms including the famous Great Red Spot. Perhaps more compelling, though, are the four large moons that accompany Jupiter – the Galilean moons. At any given moment, up to four are visible flanking the planet, though one or more are often obscured by the planet or immediately in front of it from our perspective. Compared with Venus, you may find that longer exposures are needed to capture Jupiter, but these will be at most just a fraction of a second. Keep shooting, too – the bluring effects of astronomical seeing will be evident at high magnification, so some shots will be sharper than others.

Jupiter's moons are relatively easy to record as bright dots of light

PETE LAWRENCE, TOM KERSS X 4

Your telescope is a lens

Many telescopes can be transformed into a giant lens by attaching a camera – including DSLRs and mirrorless cameras

9. The Moon up close

Combining your camera with a telescope can bring out a view of the Moon that's usually hidden

Even short telescopes are equivalent to powerful telephoto lenses, and longer scopes go far beyond the range offered by camera lenses. A 1.5m-focal-length telescope, for example, can project the face of the Moon across a DSLR sensor, almost edge to edge. With thousands of pixels sampling its rugged surface, remarkable details are revealed. Owing to its brightness, the Moon is a forgiving target at such long focal lengths. You don't need tracking (although it does help) to achieve great results. And it's not just spatial details that come into view. With high-resolution images of the Moon, we can draw out its subtle colours using image-processing software. By enhancing the saturation and vibrance of the image, we can see the chemical variance of the lunar surface. These colours are virtually imperceptible to the eye, even with a large telescope and lots of observing experience.

Upping the saturation will add a colourful dimension to your Moon shots

10. The Pleiades

With a powerful lens you'll be able to capture many of the Seven Sisters' siblings

As with our earlier look at deep-sky targets, a properly aligned tracking mount is essential when using your telescope to capture the stars, but the results are worth the effort. Using a fast, widefield telescope, you can turn your camera into a powerful astro-imaging tool, and the Pleiades star cluster is the ideal target to sharpen your imaging skills. The goal is to draw out fainter members of the cluster, the rich, blue colour of its prominent stars and the delicate reflection nebula in its vicinity. By practising your exposure stacking and image processing, you'll be able to turn out results that dramatically improve on anything offered by a single photo. Errors in tracking are punishing, but the Pleiades is one of the brightest deep-sky objects, and you'll be able to get away with exposures ranging from 10 to 30 seconds, depending on your telescope's aperture and camera ISO setting. Have fun experimenting, and good luck with your first steps in astrophotography!

The Pleiades is one to return to again and again to draw out more detail and subtle nebulosity

Capturing a first: the Spin Nebula

Amateur astronomers work collaboratively to produce first high-resolution image of little-known nebula He 2-11

Teamwork makes the dream work, says the old cliché... and it's a maxim that proved true for ShaRA, a group of amateur astronomers who, through their collaborative efforts, recently produced the first high-resolution image of a distant planetary nebula.

The group of 22 mostly Italian astronomers started the ShaRA (Shared Remote Astrophotograph) project as a way of pooling both their financial resources to buy imaging time on large telescopes, and their technical skills to obtain the best results from the collected data.

Most recently, they decided to look at the Gum 14/15 nebula complex, a pair of neighbouring emission nebulae in the constellation of Vela. Few amateur images of this region exist, but using Atacama-based Chilescope's T5 telescope, the group managed to capture the stunningly detailed widefield image seen here.

Things started to get really interesting, though, when group members noticed a small object in the top-left of the image that had the typical appearance of a planetary nebula. Some digging through astronomical databases and catalogues revealed that this had to be He 2-11, which was first described by US astronomer and astronaut Karl Henize in 1967.

Henize's suggestion that this was a planetary nebula was confirmed by further research in 1999, while in 2014 closer analysis based on data from the Chandra Observatory revealed it to be one of just three such nebulae known to have a variable binary as its central star(s).

All interesting stuff, but in terms of images, all that existed of He 2-11 was still just a handful of blurry black and white pictures. Accordingly, the ShaRA team booked some more time from Chilescope, this time using its T1 telescope – and so, many hours of observing and processing time later, were eventually able to produce the detailed, first-of-its-kind colour image seen in the inset.

The ShaRA team have since nicknamed He 2-11 'the Spin Nebula' – a nod to its fast-rotating central binary – and say their hope is that their image will encourage other amateur astronomers to keep on pushing themselves ever further.

SHARA TEAM

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Big or small, every legacy gift left to the Stroke Association will make a difference to stroke survivors and their families.

Find out how by calling 020 7566 1505

or email legacy@stroke.org.uk

or visit stroke.org.uk/legacy

Rebuilding lives after stroke

Stroke Association

BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

SEPTEMBER 2023

BRILLIANT VENUS

After its beautiful evening appearance during the first half of 2023, Venus is now dominating the early morning sky

BINO BEAUTIES

Hunt for widefield gems around Aquarius

FIND A CITY ON THE MOON!

Spot the lunar light effect on 8 September

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- A busy month of meetings for the Moon
- Neptune at opposition
- Catch asteroid Thisbe
- Mercury at greatest western elongation

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

SEPTEMBER HIGHLIGHTS

Your guide to the night sky this month

Friday 1

The Alpha Aurigid meteor shower reaches its peak today.

The 'equation of time' – the difference between time reported by the artificial 'mean Sun' and the apparent Sun – equals zero, meaning sundial shadows report the correct time today!

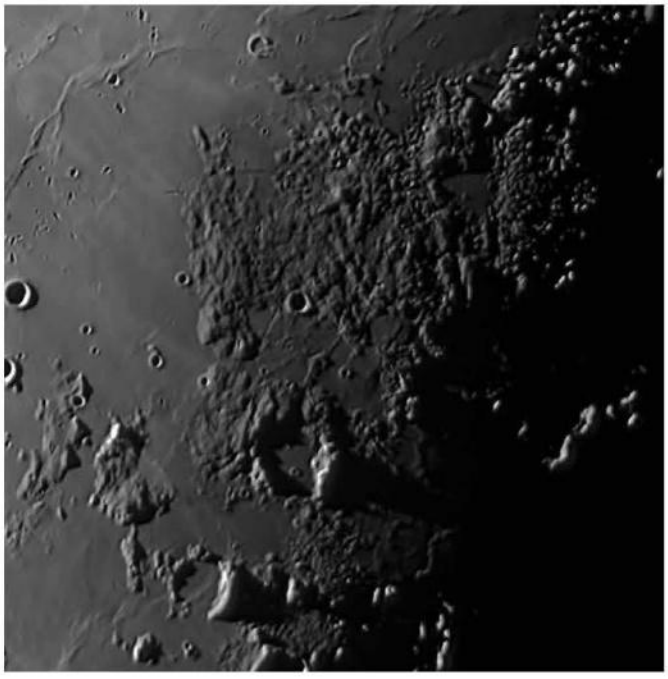
Monday ▶ 4

This evening has a 70%-lit waning gibbous Moon located 3.3° northeast of mag. –2.5 Jupiter. Catch the pair rising above the east-northeast horizon from around 22:00 BST (21:00 UT).

Tuesday 5

The waning gibbous Moon sits near Uranus and Jupiter (see page 46), occulting mag. +4.3 Botein (Delta (δ) Arietis) around 04:45 BST (03:45 UT).

This evening the 60%-lit Moon sits near the Pleiades.



◀ Thursday 7

An opportunity to see the clair-obscur effect known as Gruithuisen's Lunar City occurs this evening, with optimum conditions around midnight BST (23:00 UT). See page 47 for details.

Friday 8

The Moon has moved sufficiently out of the way to allow you to take our monthly Deep-Sky Tour. Turn to page 56 and take a look at some of the objects on the Lacerta–Cepheus border.

Thursday ▶ 14

A chance to spot a thin Moon occurs this morning, with a less than 1%-lit waning crescent Moon rising one hour before sunrise. Mag. +1.8 Mercury sits 6.3° to the right of the Moon. See page 46 for details.

Friday 22

Mercury reaches greatest western elongation. At this time it'll be separated from the Sun by 17.9° and visible in the morning sky at mag. –0.3.

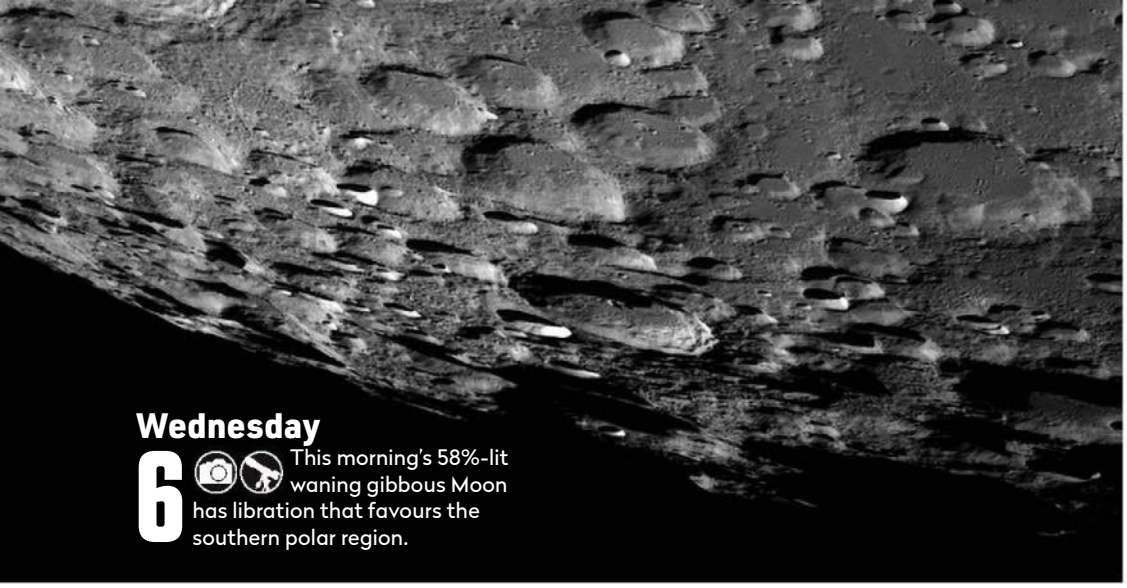
Saturday ▶ 23

The centre of the Sun crosses the celestial equator at 07:50 BST (06:50 UT), the Sun moving from the northern celestial hemisphere to the southern celestial hemisphere. This instant in time marks the Northern Hemisphere's autumn equinox.

Family stargazing

As the full Moon rises on the evening of 29 September (low on the east horizon just after sunset), when it's close to the horizon it will appear absolutely huge. The apparent size is an illusion. Using various-sized stones, lay them out on a piece of paper. Ask which size stone at arm's length matches the size of the Moon, then suggest holding the selected stone up at arm's length next to the Moon. The result will be surprising! If clouds interfere on the 29th, as it rises slightly later on the following evenings, the effect should still be noticeable. **www.bbc.co.uk/cbeebies/shows/stargazing**

PETE LAWRENCE X 8



Wednesday
6 This morning's 58%-lit waning gibbous Moon has libration that favours the southern polar region.

Saturday ▶
9 Magnitude –4.4 Venus currently sits 0.9° south of the seventh-magnitude open cluster M67 in Cancer.

Monday
11 Early risers will catch a 12%-lit waning crescent Moon 3.3° north of the Beehive Cluster, M44. Magnitude –4.4 Venus sits 9.4° south-southeast of the cluster too.

Monday
18 Visible in the morning sky, Venus is currently at its brightest, shining at around mag. –4.5.

Wednesday ▶
20 Neptune reaches opposition today, when it will be at mag. +7.8, south of the Circlet in Pisces.

Sunday
24 The 72%-lit waxing gibbous Moon this evening has libration that favours the northern polar region.

Monday
25 This month's Moonwatch target (see page 52) is the crater Vitello on the southern shore of Mare Humorum. The two windows of opportunity to see it at its best occur on 9–10 September and tonight and the next night, 25–26 September.

Wednesday
27 This morning at around 02:30 BST (01:30 UT), as it approaches setting, the 91%-lit waxing gibbous Moon will lie 3.6° from mag. +0.5 Saturn.

Friday ▶
29 The Moon is full at 10:57 BST (09:57 UT), just 32 hours 52 minutes after it reaches perigee, its closest point to Earth. This makes today's full Moon a perigee full Moon. Being closest to the September equinox, it's the Harvest Moon for 2023.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The top sights to observe or image this month

DON'T MISS

Moon events

BEST TIME TO SEE: Various times

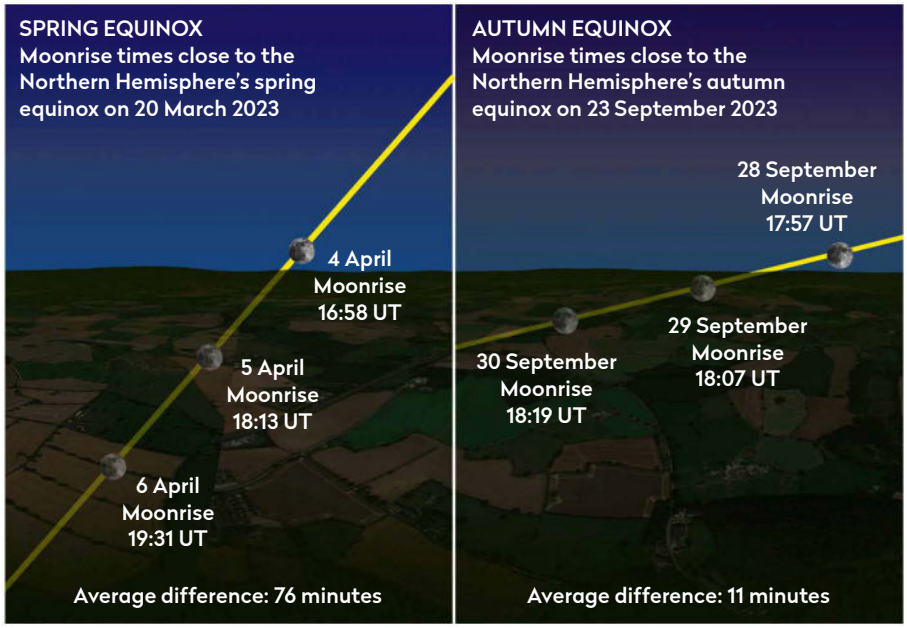
The full Moon on 29 September occurs 32 hours 52 minutes after lunar perigee, the point where the Moon is closest to Earth in its orbit. Also known as a supermoon, it will appear subtly larger and brighter than average, and is the last one this year. This full Moon is also less than a week after the September equinox, which occurs at 07:50 BST (06:50 UT) on 23 September and as the closest full Moon to it, it's the Harvest Moon for 2023.

The Harvest Moon's name is quite appropriate in that it references a real effect. During its near-to-full phases around the September equinox, the differences in time between moonrises from one day to the next are at a minimum. This is a consequence of the geometric combination of Earth's orbit around the Sun and the Moon's orbit around Earth.

This minimal difference – typically less than 15 minutes between September moonrise times from one evening to the next – contrasts with when differences are at their maximum, and there's over an hour between moonrise times at the fuller phases near to the March equinox. Rising at similar times in September, the fuller phases of the Moon light the fields for harvest collection, hence the name.

Earlier in the month on 4 September, catch the 70%-lit waning gibbous Moon rising near mag. –2.5 Jupiter around 22:00 BST (21:00 UT). Follow this Moon through into the morning of 5 September and you'll see it occult mag. +4.3 Botein (Delta (δ) Arietis) at around 04:44 BST (03:44 UT). Later that evening, the now 60%-lit waning gibbous Moon lies 2.2° from the Pleiades open cluster.

On the evening of 7 September, there's an opportunity to spot the odd and not immediately obvious region on the Moon that creates a clair-obsur effect known as Gruithuisen's Lunar City (see opposite). It's perhaps grander in name than in appearance, but still worth looking for.



▲ **The moonrise times around the Northern Hemisphere's spring equinox and autumn equinox differ dramatically. In autumn, moonrise times barely change from day to day**

As the Moon continues to wane, on the morning of 11 September, at 12% illumination, it sits 3.3° to the north of the Beehive Cluster, M44. Mag. –4.4 Venus is located 9.4° south-southeast of the cluster at this time too.

Eventually, the Moon's waning brings it to the very thin crescent phase. On the morning of 14 September, see if you can spot its less than 1%-illuminated crescent rising above the eastern horizon an hour before sunrise. If you do manage to find it, commit it to memory and then compare it when you're staring up at that really bright perigee Harvest Moon on 29 September.

A beautifully tricky, very thin crescent Moon is visible on the morning of 14 September

ALL PICTURES: PETE LAWRENCE

Gruithuisen's Lunar City

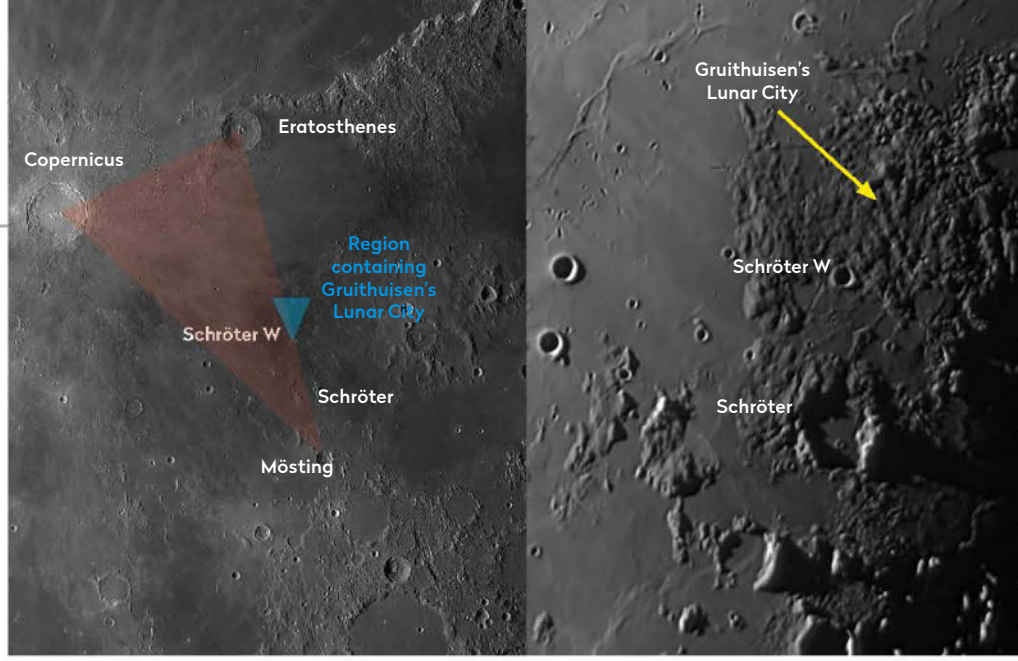
BEST TIME TO SEE: 8 September, from 01:00 BST (00:00 UT)

If nothing else, Gruithuisen's Lunar City sounds rather grand. The reality is not quite so impressive, but this is still an interesting clair-obscur effect to track down. In order to see the 'city', the position of the evening terminator has to be right. This is measured by a value known as co-longitude and can be obtained for a given date and time from free software such as WinJupos (**jupos.org/gh/download.htm**) and the Virtual Lunar Atlas (**ap-i.net/avl/en/start**). Here we need a co-longitude of 185.0° with the Moon just past last quarter. This occurs on 8 September at 01:05 BST (00:05 UT).

It's not a real city of course, but rather a lighting effect making a small section of the Moon appear to have linear streets and buildings. Finding it can be challenging. The 'city' is located using giant craters Copernicus (93km) and Eratosthenes (60km). Imagine them forming one side of a large isoceles triangle. The other point is marked by the smaller 27km crater Mösting, further to the south and near the terminator.

Starting at Mösting, head back along the line towards Eratosthenes. About one-fifth of the way you'll arrive at heavily eroded 35km Schröter, a crater that appears to have lost its southern rim. Keep going towards Eratosthenes and the next obvious crater is Schröter W which has a diameter of 10km. Schröter W has a smaller 3km crater, Schröter A, inside it which will be in darkness when the terminator is nearby. The 'streets' of Gruithuisen's City appear from the shadows cast in the highland region to the north and east of Schröter W.

The feature was named at a time when it was thought the Moon was populated. It was discovered in 1824 by Franz von Paula Gruithuisen, who made multiple observations of it, calling the city 'Wallwerk'.



▲ **Can you spot the lighting effect Gruithuisen's Lunar City on the morning of 8 September?**

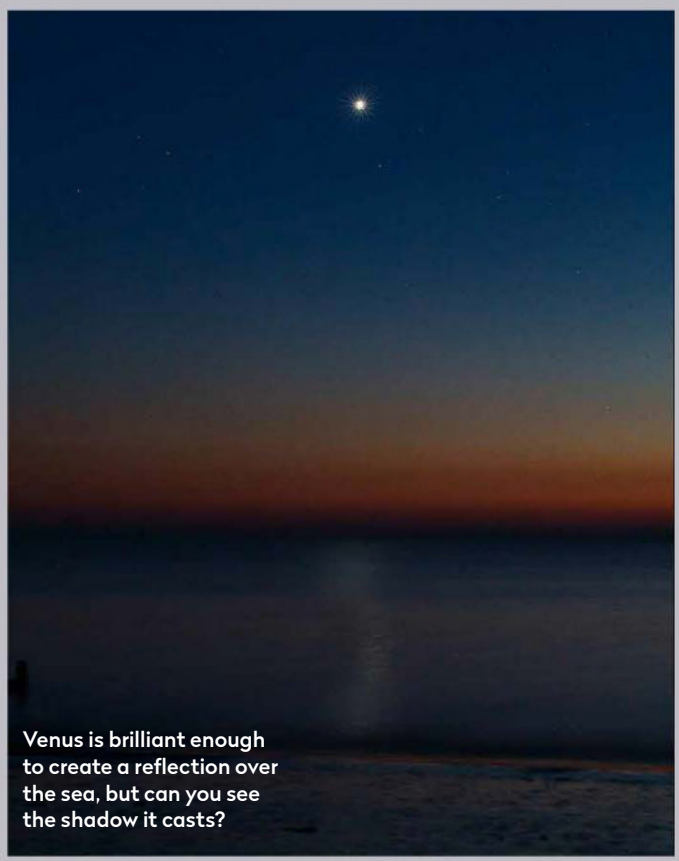
Venusian shadow

BEST TIME TO SEE: From 15–26 September

Venus is intensely bright at present, currently shining in the morning sky at nearly mag. –4.5, the brightest it can reach. At the start of the month, it's well-placed and can't be seen against a dark sky as it rises only two hours before the Sun. However, that changes throughout September and by the end of the month, rising nearly four hours before sunrise, there's a chance to see this dazzling jewel of a planet against an astronomically dark sky. The light from Venus is intense and effectively a point source.

On 15 September, after rising, Venus remains against astronomically dark skies for around 80 minutes, reaching an altitude of 10° as astronomical darkness comes to an end. By the end of the month, Venus is visible under astronomical darkness for two hours, reaching an altitude of 18° before true darkness ends.

Catch it from mid-month onwards, before the Moon interferes, and there will be an opportunity to see it casting a shadow. The Venusian shadow is quite something, as the point-source nature of the planet creates razor-sharp shadow edges. The only problem is that the shadow is very faint and easily lost. Turn to our Sky Guide Challenge **on page 55** to find out how to record this rare planetary effect.

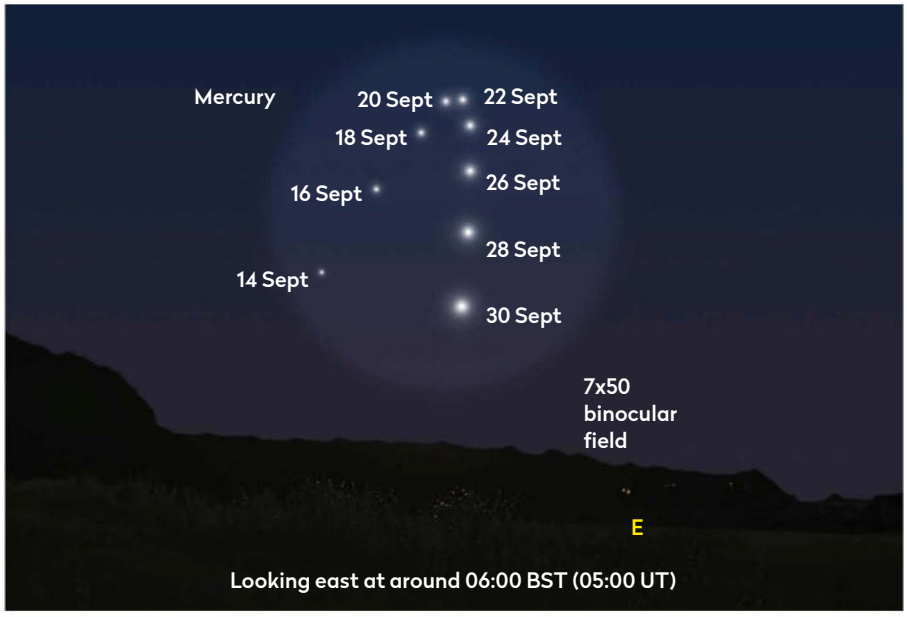


Venus is brilliant enough to create a reflection over the sea, but can you see the shadow it casts?

PICK OF THE MONTH

Mercury

Best time to see: 22 September, from 1 hour before sunrise
Altitude: 7° (low)
Location: Leo
Direction: East
Features: Phase, surface markings
Recommended equipment: 150mm or larger



▲ **Mercury's morning position on the run-up to and after greatest western elongation**

Mercury isn't visible at the start of the month when it will be an evening object setting before the Sun and too faint to be seen under daytime conditions. Inferior conjunction occurs on 6 September when Mercury lines up with the Sun, passing 3.8° to the south of the Sun's centre.

After inferior conjunction, Mercury emerges into the morning sky. Unlike the situation in the evening sky – where the shallow angle of the ecliptic with the western horizon at sunset forces the evening twilight planets into a poor position for observing – in the morning sky, the ecliptic angle with the eastern horizon at sunrise is steep. Consequently, Mercury's morning appearance will be much more favourable.

Having said this, at first Mercury will be difficult to see against the bright dawn twilight. Things improve by the time of greatest western elongation on 22 September. That morning it shines at mag. –0.3 and rises over 100 minutes before the Sun.

At greatest western elongation, Mercury appears separated from the Sun by almost 18°, a figure that then begins to decrease. Despite this, it remains good for the rest of September. It increases in brightness, reaching mag. –0.9 on the morning of 30 September. On this date, despite closing in on the Sun, Mercury's steep position means it rises 90 minutes before the Sun.

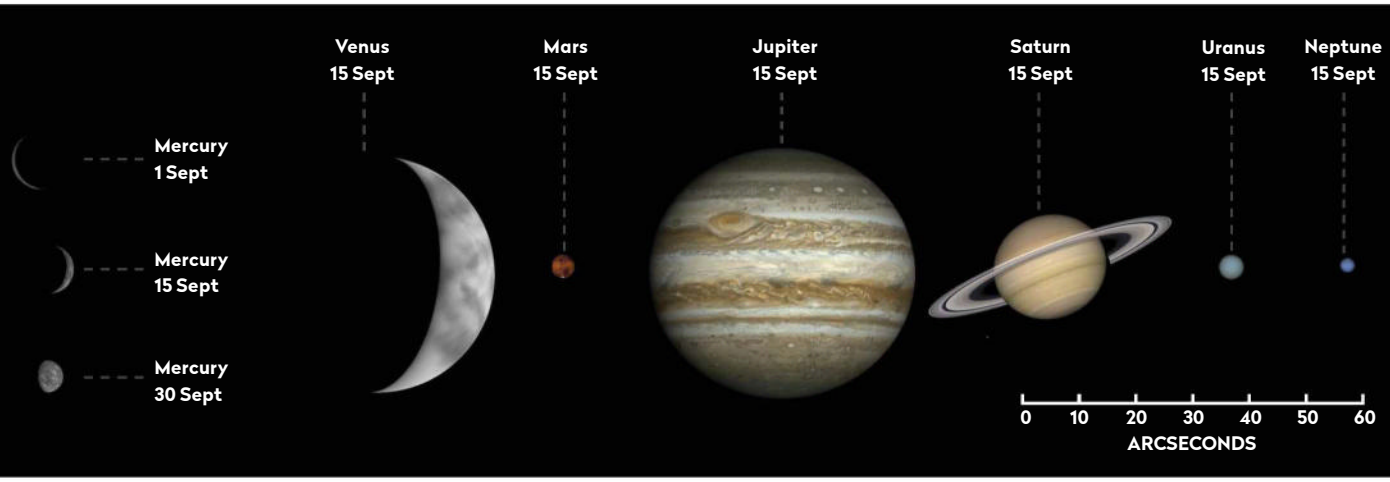
▲ **Being an inferior planet, Mercury shows phases when viewed through a telescope**

Being an inferior planet, Mercury shows phases. Through the eyepiece, it appears a fraction under half-lit on the morning of 22 September and 7 arcseconds across. By the end of the month, its phase will have increased to 79%-lit, its apparent diameter having decreased to 5 arcseconds.

PETE LAWRENCE X 2

The planets in September

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Venus

Best time to see:
30 September, 05:15 BST (04:15 UT)
Altitude: 18°
Location: Leo
Direction: East
A morning object shining at mag. –4.3 at the start of the month and rising almost 2 hours before the Sun. As it approaches greatest western elongation next month, its position improves; by 30 September it rises 4 hours before the Sun, allowing views against astronomically dark skies for over 2 hours. Through the eyepiece, Venus appears 11%-lit and 49 arcseconds across on 1 September. It is 35%-lit and 32 arcseconds across by month's end.

Mars

Not visible

Jupiter

Best time to see:
30 September, 05:15 BST (04:15 UT)
Altitude: 52°
Location: Aries
Direction: South
A prominent morning planet, shining at mag. –2.5 in southern Aries. Visited by a bright waning Moon on the mornings of 4 and 5 September, it just fails to reach its highest position, due south, under dark sky conditions on these dates. This occurs from the middle of the month, Jupiter reaching 52° altitude from the centre of the UK, lifting it well above low-level turbulence.

Saturn

Best time to see: 1 September, 22:50 BST (21:50 UT)
Altitude: 24°
Location: Aquarius
Direction: South
Saturn was at opposition at the end of August and remains well-placed for observation. Currently in Aquarius, Saturn reaches its highest point in the sky, due south, all month under dark sky conditions.

Through a telescope, the rings currently have their northern face tilted towards us by around 10°. A bright 91%-lit waning gibbous Moon sits 3.3° south of mag. +0.5 Saturn as the pair approach setting on the morning of 27 September.

Uranus

Best time to see:
30 September, 03:50 BST (02:50 UT)
Altitude: 55°
Location: Aries
Direction: South
Morning planet Uranus reaches its highest altitude, due south, under dark sky conditions from the middle of the month. Jupiter and Uranus appear 7.5° apart on the morning of 7 September, the gap increasing to 8.2° by the end of the month. Uranus shines at mag. +5.7 and although technically visible to the naked eye from a dark site, is best confirmed using binoculars.

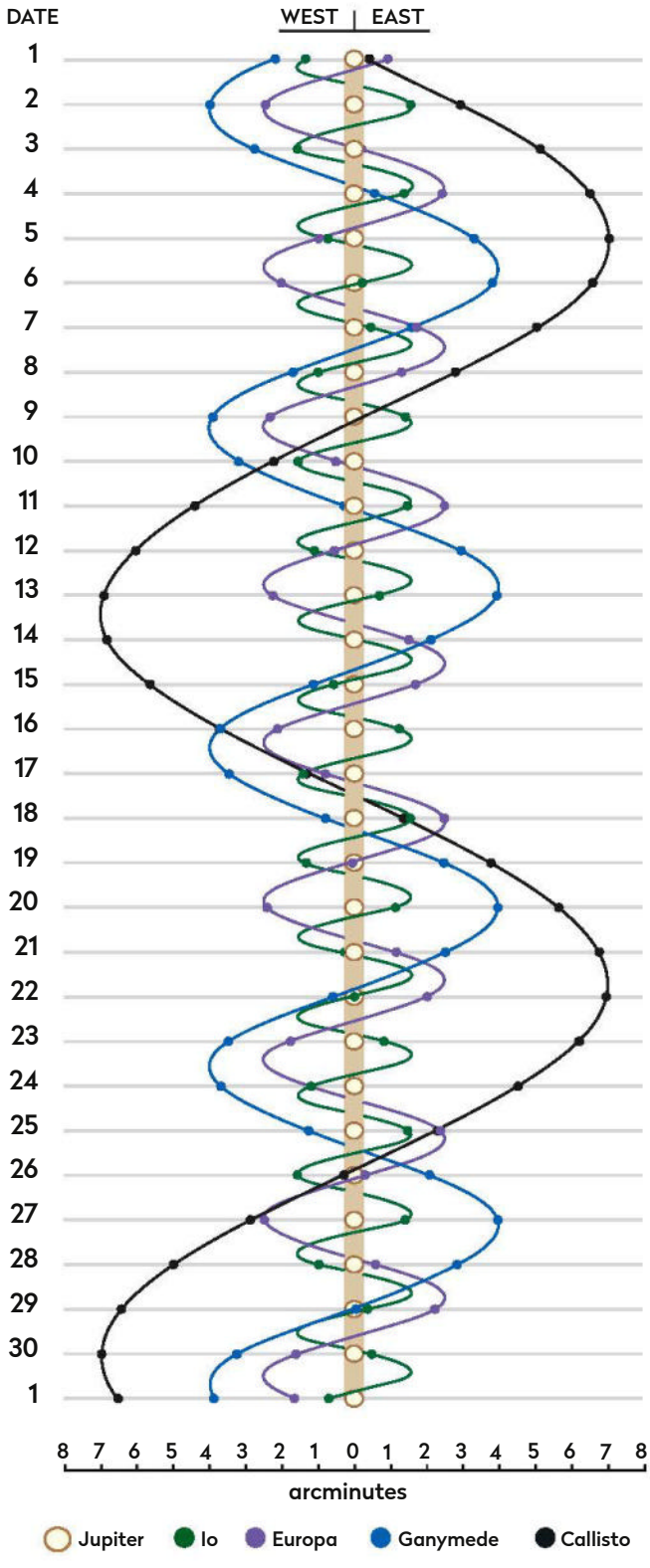
Neptune

Best time to see:
20 September, 01:00 BST (00:00 UT)
Altitude: 34°
Location: Pisces
Direction: South
Neptune reaches opposition on 20 September. The planet achieves 35° when due south under dark sky conditions all month long. A telescope is required to show its tiny blue-hued disc. At mag. +7.8, Neptune isn't visible to the naked eye, requiring at least a pair of binoculars to see.

MORE **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: SEPTEMBER

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – SEPTEMBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 September at 01:00 BST
15 September at 00:00 BST
30 September at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in September*

Date	Sunrise	Sunset
1 Sept 2023	06:19 BST	20:00 BST
11 Sept 2023	06:36 BST	19:36 BST
21 Sept 2023	06:53 BST	19:12 BST
30 Sept 2023	07:11 BST	18:48 BST

Moonrise in September*

Moonrise times

1 Sept 2023, 20:47 BST	17 Sept 2023, 09:18 BST
5 Sept 2023, 21:42 BST	21 Sept 2023, 14:40 BST
10 Sept 2023, 00:41 BST	25 Sept 2023, 18:08 BST
13 Sept 2023, 04:24 BST	29 Sept 2023, 19:04 BST

*Times correct for the centre of the UK

Lunar phases in September

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15 NEW MOON	16	17
18	19	20	21	22	23	24
25	26	27	28	29 FULL MOON	30	

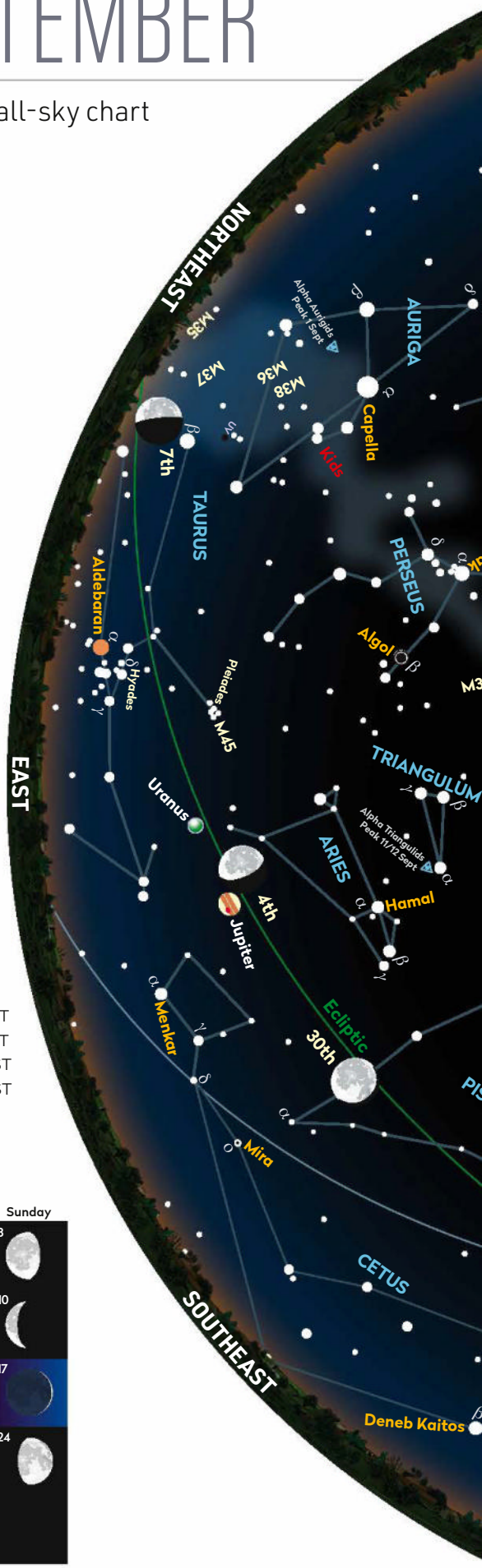
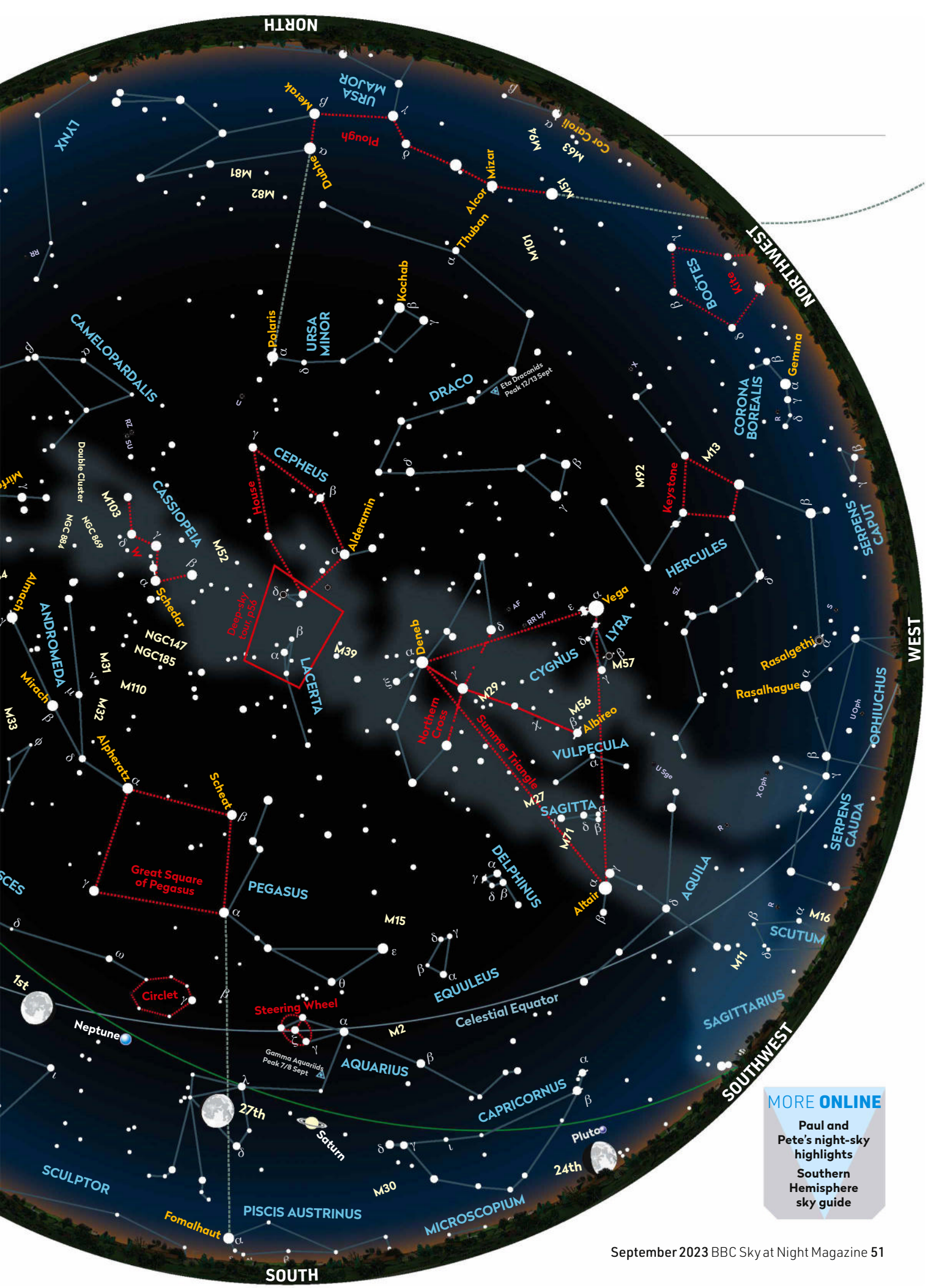


CHART: PETE LAWRENCE



MORE **ONLINE**

Paul and Pete's night-sky highlights

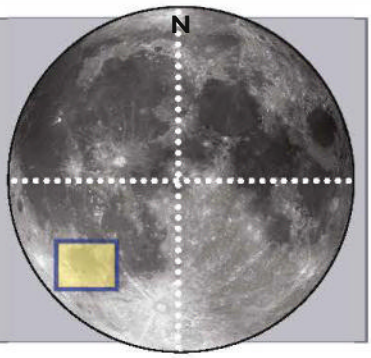
Southern Hemisphere sky guide

MOONWATCH

September's top lunar feature to observe

Vitello

Type: Crater
Size: 41km
Longitude/latitude: 37.6° W, 30.4° N
Age: Around 3.8–3.9 billion years
Best time to see: 3 days after first quarter (25–26 September) or 2 days after last quarter (9–10 September)
Minimum equipment: 50mm refractor



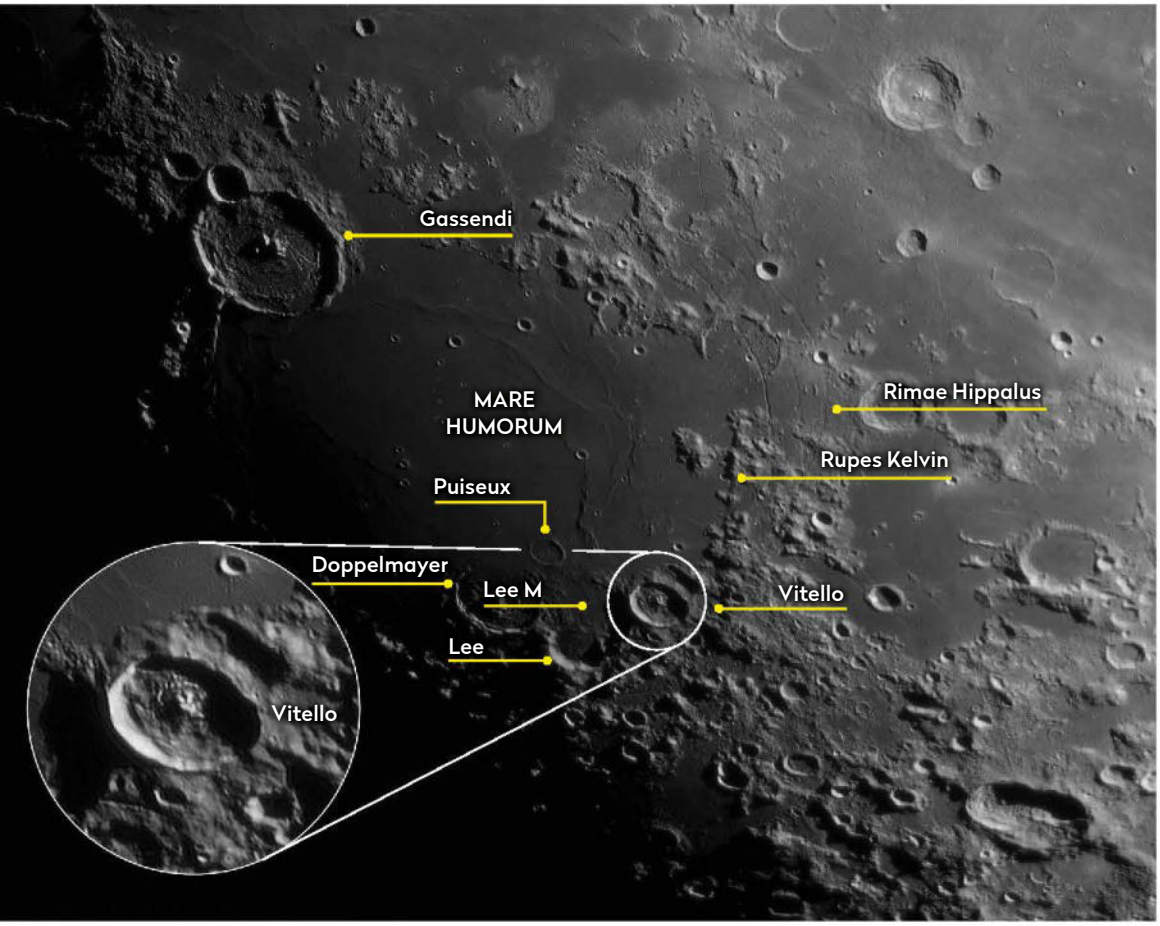
Vitello is a 41km crater located on the southern border of 380km-diameter **Mare Humorum**. Positioned in the southwestern quadrant of the Earth-facing side of the Moon, it's best seen as the Moon is in its waxing gibbous to waning crescent phases. The phases that occur near and after last quarter are better placed in the morning sky at this time of year, so a late night or early start will get you the best views of this region of the Moon.

Vitello is impressive in that it's fairly old, but retains many of its youthful looks. Its rim is remarkably well-preserved and shows amazing regularity in its width all the way around, with the possible exception of a small valley to the south. The preserved state is all the more remarkable when you compare Vitello to its immediate neighbours, 77km **Lee M**, 41km **Lee**, 65km **Doppelmayer** and 25km **Puiseux**. Why? Well, each of those craters is lava-flooded and, with the exception of Puiseux, have lost a significant rim section. Puiseux retains its rim but has lost its floor!

Vitello has both its rim and floor intact. It sits on an elevated highland section just south of Humorum's lava floor and this fortuitous location is what has preserved it. The internal rim is striking because it slides down from the rim edge to the crater's floor with little in the way of terracing, except in the southern section where a series of undulating concentric ridges are seen. The rim rises around 1.5km above the lava surface of Mare Humorum, Vitello's floor lying 600m below the rim edge.

The interior floor is rugged and complex, rewarding views from different apertures of telescope with different levels of detail. The most obvious feature is the central mountain complex which consists of several peaks all converging in the centre of the crater. The peaks appear to sit on a circular platform bordered by intricate rilles. These are fascinating to observe when the lunar terminator is close by, oblique lighting emphasising their complex form. Although they look concentric, high-resolution images may reveal a radial component, most evident in the northeast section of the floor. The area between the circular cracks and the rim is filled with undulating hills in the east, north and west sections, with those terrace waves mentioned earlier, in the south.

▼ **Surprisingly well-defined for its age, Vitello has a dense central mountain complex that reveals itself under larger apertures**



The whole of the Humorum region is fascinating to explore. When the lighting is ideal for Vitello, it's also good for 110km **Gassendi** which lies on the north shore, opposite Vitello. Like Vitello, Gassendi has a complete rim surrounding an intricately cracked floor with a central mountain complex. It's interesting to switch between both craters, comparing similarities. In addition, when the eastern border of Humorum is visible, don't miss the superb **Rimae Hippalus**. These are a series of rilles, approximately 240km in length, that form arcs concentric with Mare Humorum. Find them by heading northeast from Vitello past **Rupes Kelvin**.

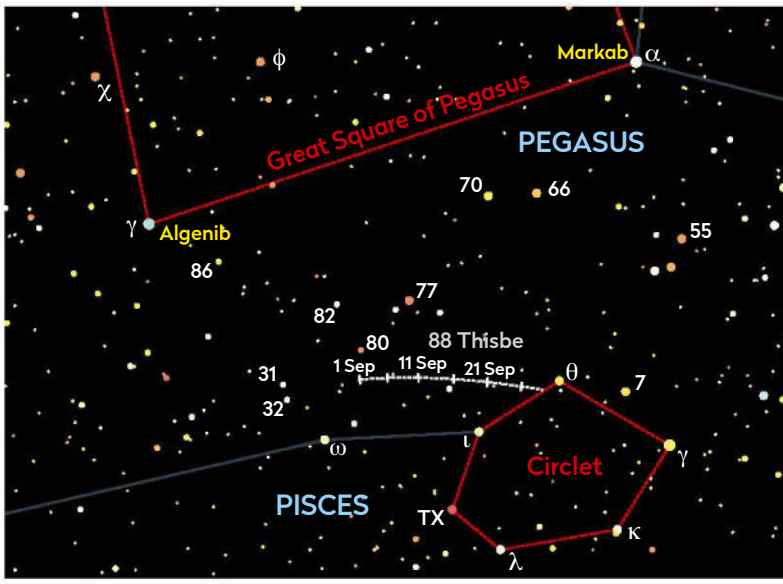
COMETS AND ASTEROIDS

A chance to catch dim minor planet 88 Thisbe as it reaches opposition

Asteroid 88 Thisbe reaches opposition on 21 September, achieving its brightest magnitude for the current period of +10.3, putting it within the reach of small telescopes or basic imaging setups. Although it technically starts the month in Pegasus, 0.8° south of mag. +5.8 80 Pegasi, Thisbe spends most of September in Pisces tracking towards the Circlet asterism. On the night of 29/30 September, Thisbe just reaches the asterism, crossing the line joining Theta (θ) to Iota (ι) Piscium, one-sixth of the way along that line starting at Theta.

If you've never tracked a dim asteroid, Thisbe is a good candidate both because of its proximity to the Circlet and due to its short 6° September track length. Chances are you may not have encountered Thisbe before. If so, it might be surprising to learn that this is the 13th-largest main belt asteroid, it's triaxial ellipsoidal dimensions being 255 x 232 x 193km.

Thisbe orbits the Sun once every 4.6 years with an orbit that takes it in as close as 2.3 AU and out as far as 3.2 AU from the Sun. Our precise knowledge of its dimensions is a testament to the 'occultation chord' method. When an asteroid passes in front of a star, it occults that star. If the occultation shadow passes over Earth, we can observe it. Due to parallax and the uneven size of the occulting body, different locations on Earth will see different lengths of occultation. Putting these together gives an approximate profile of the occulting body. In 1981, the ninth-magnitude star SAO 187124 was observed to be occulted by Thisbe from a dozen separate sites. Analysing the observations subsequently led to a size estimate that was 10 per cent larger than previously thought.



▲ **Follow 88 Thisbe's short track towards the Circlet this month**

STAR OF THE MONTH

Kitalpha, the 'emptiness' in the head of a horse

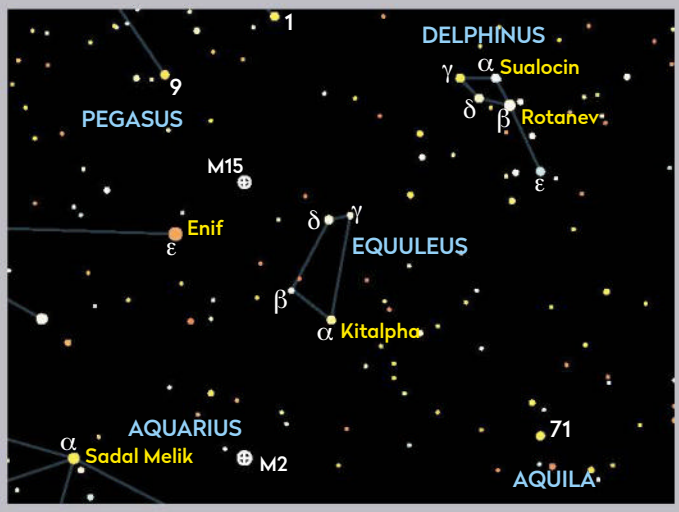
Equuleus the Foal is a small, rather faint constellation of the autumn sky. It's the second-smallest constellation by area and sits between Delphinus and Aquarius. It also borders Pegasus, to the east.

Although this may sound unkind, it is fair to say that Equuleus isn't much to look at. It is depicted as an irregular quadrilateral shape formed from Alpha (α), Beta (β), Delta (δ) and Gamma (γ) Equulei, which have magnitudes of +3.9, +5.2, +4.5 and +4.7 respectively. As you can tell, Equuleus isn't a bright constellation!

The name Kitalpha gives the impression it relates to the star's Bayer letter designation of alpha, but this is not the case. 'Kitalpha' comes from the Arabic meaning 'part of a horse'. The Chinese name 'Xū Sù' relates to the line formed from Alpha and Beta Equulei, the name meaning 'Emptiness'. In Chinese, Alpha is named 'Xū Sù èr' – 'the Second Star of Emptiness'. Staring at the star in the autumn night sky, it's quite amazing how this description resonates.

Located 190 lightyears away, as with many naked-eye stars, despite its relative faintness Kitalpha still manages to put us in our place, being 2.3 times more massive, 9.2 times larger and 53 times more luminous than the Sun.

▼ **Kitalpha (Alpha Equulei) is a faint hypergiant in Equuleus the Foal**

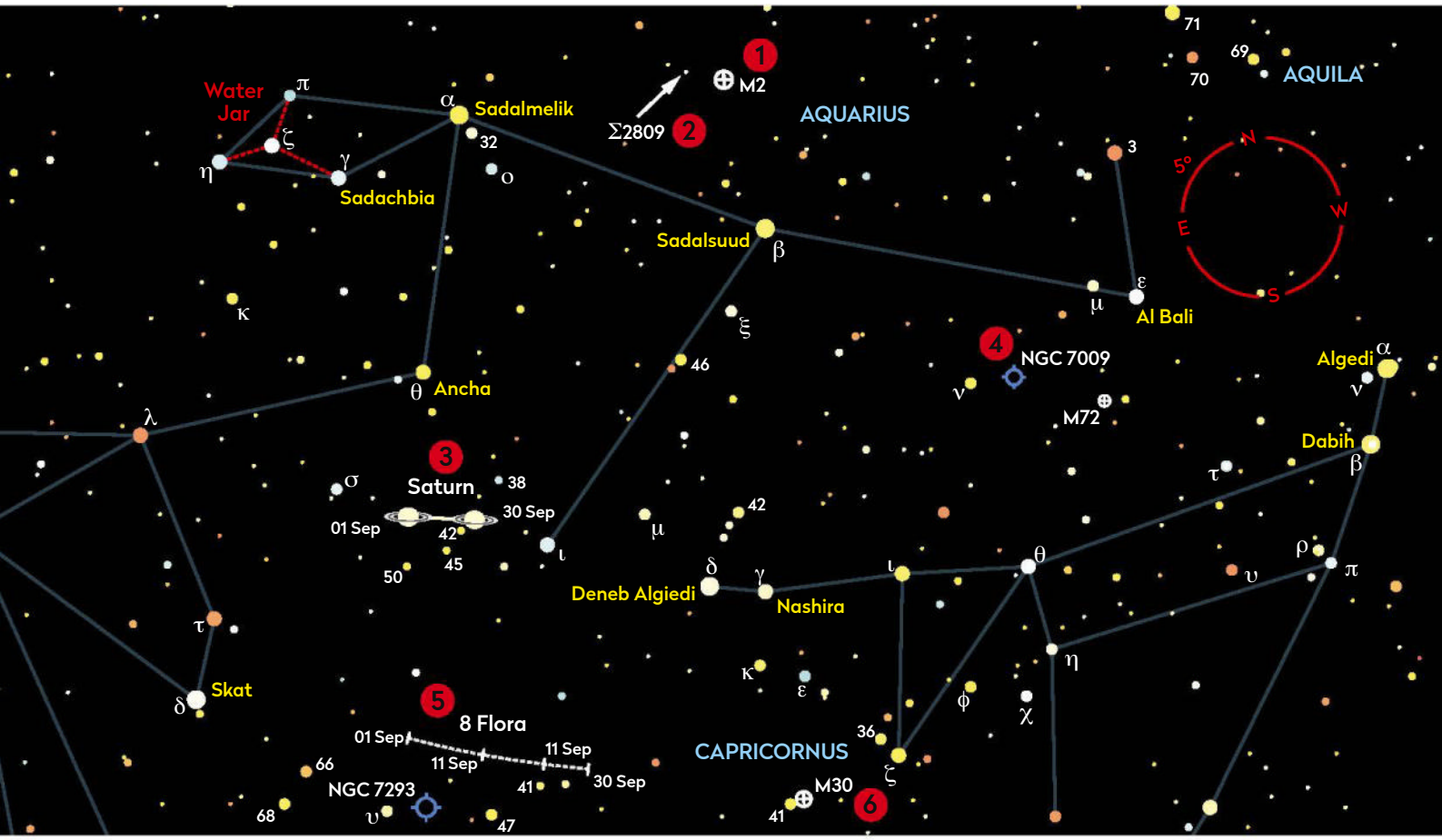


It also has the very complex spectral classification G7III + kA3hA4mA9, 'G7' indicating it's a yellow sun, 'III' a main-sequence dwarf. The rest relates to an Am-type dwarf star companion so close that their spectra overlap.

BINOCULAR TOUR

With Steve Tonkin

Our tour near Aquarius has it all, from clusters to planets, double stars and an asteroid



1. M2

10x50 Charles Messier described the globular cluster M2 as "a nebula without stars". You'll find it due north of Sadalsuud (Beta (β) Aquarii) and due west of Sadalmelik (Alpha (α) Aquarii). It's obvious in a star-sparse region of sky; even in small binoculars you should be able to see this 38,000-lightyear-distant glow. If you use averted vision, it will appear to grow slightly and may appear very slightly oval in shape. ☐ **SEEN IT**

2. Σ2809

10x50 From M2, head slightly more than a degree east-northeast to a mag. +6.2 star. This is the brighter component of a double-star system, Struve 2809. Seeing the fainter companion is a good test of both 10x50 binoculars and your observing technique, because it's a mere 31 arcseconds to the south-southeast and shines at only mag. +9.3. Don't expect to see it consistently; it may 'fade' in and out of visibility. ☐ **SEEN IT**

3. Saturn and Titan

10x50 Saturn is the brightest object in the area covered by the chart, so is easy to locate. You won't see the rings in 10x50 binoculars, but you can see the brightest moon, Titan, which shines at mag. +8.4. Its period of orbit around Saturn is nearly 16 days and its angular distance from the planet ranges between 0.5 and 3 arcminutes, so the second-largest moon in the Solar System is quite easy to spot. ☐ **SEEN IT**

4. The Saturn Nebula, NGC 7009

15x70 If you want a good binocular observing challenge in British skies, this is a top candidate. Fortunately, it's very easy to locate, 1.3° due west of mag. +4.5 Nu (ν) Aquarii. It appears as a slightly defocused star but, because it's only about 0.4 arcminutes across, at this magnification you'll not be able to see the elongation that Lord Rosse detected when he gave it its common name. ☐ **SEEN IT**

5. 8 Flora

15x70 Here's a rare opportunity to spot asteroid 8 Flora in binoculars. It starts the month at mag. +8.5, 6.7° south of Saturn and fades by a bit more than half a magnitude as it tracks 5° west-southwest during the month. It will be hard to identify against the background stars, so you'll need to observe on several occasions to detect which of these 'stars' moves in relation to the others. ☐ **SEEN IT**

6. M30

10x50 If you plan to do a Messier Marathon (observing all 110 Messier objects between dusk and dawn) next spring, M30 is one you need to be confident of finding, being the difficult last object in a lightening dawn twilight sky. Autumn evenings are a very good time to start this practice. You'll find it half a degree from mag. +5.2 41 Capricorni in the direction of mag. +3.7 Zeta (ζ) Capricorni. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 2

THE SKY GUIDE CHALLENGE

Venus is so bright this month that it actually casts a shadow. See if you can record it

Venus reached inferior conjunction on 13 August, a moment marking when the planet lined up with the Sun, technically moving from the evening to the morning sky. The planet's current re-emergence into the morning sky will be dramatic and as it will be visible against a dark sky there's an opportunity to photograph the shadow it can cast. This is the subject of this month's challenge.

Being nearer the Sun than Earth and enshrouded by a thick, reflective atmosphere, Venus appears very bright in our sky. Around mid-September it reaches magnitude –4.5, and under dark skies towards the end of the month the effect will be striking. This is the perfect opportunity to photograph the delicate shadow it can cast. Don't expect this to be easy though, as the Venusian shadow is – like the cloud markings on the planet itself – very subtle.

You'll need a receptacle with a dark interior, a shadow-casting object, a screen and a camera. The receptacle could be as basic as a cardboard box, with one side open and pointed towards Venus. The target can be mounted in the open end of the box. The screen doesn't need to be anything fancy either: a few sheets of white paper or card stuck cleanly to the rear of the box will do. If you have a sheet that can cover the rear area without seams, even better.

Alternatively, a room with an east-facing window can work too, but you'll need to make sure that every light source affecting the room is off. Open the window, placing your shadow-casting object up on the sill. You'll still need a screen oriented so that its plane is perpendicular to the line passing from Venus through the object.

For the camera exposure, use a mid ISO and experiment with bracketed shutter times of 10, 20 and 30 seconds. What you will get depends on your setup, so carefully examine the results. Taking several shots in succession will allow you to flick between them, something which may emphasise the shadow. If you have to go longer in terms of exposure, be aware that Venus will be moving as Earth rotates and this will blur the otherwise sharp-edged shadow.

A wide-open lens (low f/number) will help keep the exposure shorter, but for this to work you'll really need to nail the focus. Set the lens to manual focus and use a torch to illuminate the screen. Manually get the focus as accurate as you can, then turn off the torch. If you're successful, the shadow is quite amazing to see. As Venus is essentially a point-source of illumination, the edges of the shadow will appear razor-sharp.

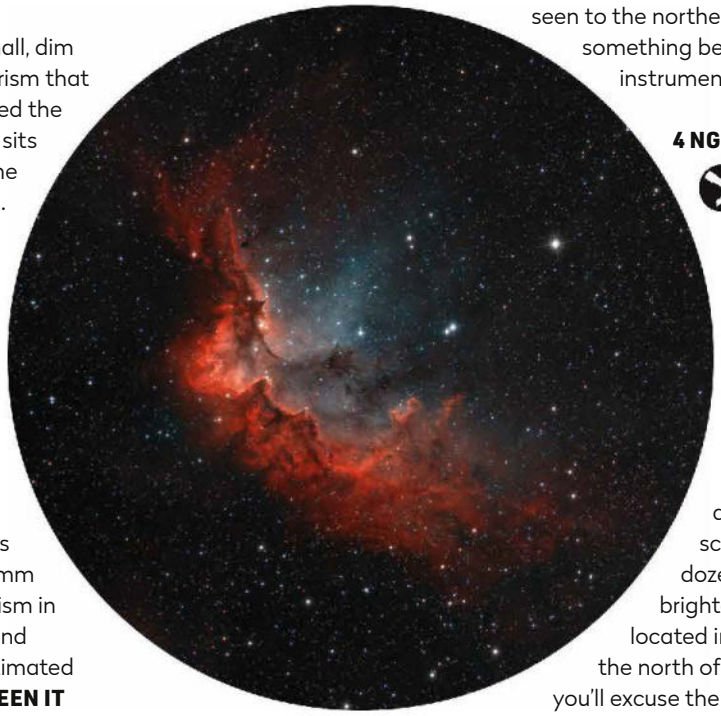
▲ A simple, low-tech setup will do. The box opening needs to be pointed at Venus and it's important that the camera isn't blocking the light from the planet. Experiment with different exposure lengths to achieve your best razor-sharp Venusian shadow

DEEP-SKY TOUR

Join our exploration of the border between the constellations Lacerta and Cepheus

1 NGC 7243

We'll start in Lacerta, a small, dim constellation with an asterism that looks like a tiny Cassiopeia, called the Mini W. Open cluster NGC 7243 sits 1.5° west of the middle star of the vertically arranged Mini W, mag. +4.5 4 Lacertae. The cluster is a fairly loose collection of blue and white stars occupying an area 21 arcminutes across. A 150mm scope shows around 40 stars. With a bit of imagination, a group of the brighter members form part of a semi-circle, reminiscent of Corona Borealis, the Northern Crown. This curve of stars shows around 25 members with a 250mm instrument, an impressive asterism in its own right. The cluster is around 2,800 lightyears distant and estimated to be 100 million years old. ☐ **SEEN IT**



▲ **The dramatic peaks of NGC 7380 in Cepheus, better known as the Wizard Nebula, a favourite target for astro imagers**

2 IC 5217

Located 1.7° northeast of NGC 7243, IC 5217 is a tiny 11th-magnitude planetary nebula known as the Little Saturn Nebula. It measures 7 x 6 arcseconds and shines with an integrated magnitude of +11.3, so it's easy to overlook it, thinking it's just a dim star. A 200mm scope will show the nebula as elongated if conditions allow you to ramp the power up. A 250mm instrument above x200 should show this elongation, the long axis of which aligns approximately north–south. This is a tricky yet rewarding object, although it has to be said it doesn't seem to carry much of a resemblance to the planet Saturn! ☐ **SEEN IT**

3 IC 1434

Our next target is IC 1434, a mag. +9.0 open cluster close to the Lacerta–Cepheus border. It lies 2° west and 0.7° north of mag. +4.4 Beta (β) Lacertae, the northernmost star in the Mini W. It's another tricky object, best seen with low to medium magnifications. It has a good mix of colour, mostly white but some obvious blue and red stars too. The cluster appears fairly loose with four brighter stars to the south. Just north of the western three of this group, photographs reveal a void area, a hole in the star field. A large curving line of faint stars can be seen to the northeast of the cluster's centre, something best picked out with larger instruments. ☐ **SEEN IT**

4 NGC 7235

We pop across the boundary from Lacerta and into Cepheus for our next target, NGC 7235. This lies 4.5° to the north of IC 1434, or 0.4° to the northwest of mag. +4.2 Epsilon (ε) Cephei. The cluster is listed as having an integrated magnitude of +7.7 but is quite small at only 4 arcminutes across. A 250mm scope will reveal just over a dozen stars in the area. The brightest star is TYC 3977-1515-1 located in the southeast corner. Just to the north of it is the real star of the show, if you'll excuse the pun, a glorious red star TYC 3997-1317-1 which shines at mag. +10.3. It's said there's the outline of a dog in the cluster stars. To be honest, you need a good imagination to see it! ☐ **SEEN IT**

5 NGC 7261

Relatively close to our last target, 1.3° further to the northeast, is another open cluster, NGC 7261, a mag. +8.4 cluster with an apparent diameter of around 6 arcminutes. Smaller scopes show around a dozen stars in a region 1.25° northeast of Epsilon Cephei. A 250mm scope shows an elongated cluster, a bit like an upside-down kite. Estimated to be just 47 million years old, the cluster contains a number of yellow members where you might expect them to be more towards the bluer end of the spectrum. The colour shift is due to intervening interstellar dust between us and the cluster. A 300mm scope reveals about 30 stars in total. ☐ **SEEN IT**

6 NGC 7380

Our final target is a popular target for astrophotography, NGC 7380, known as the Wizard Nebula. Delta (δ) Cephei lies 1.2° east and fractionally north of our last target and marks the stop-off for the Wizard, the nebula located 2.4° to the east of this famous variable star. Well, we say the Wizard is there, but through amateur telescopes you may have a hard time finding him visually. What you will be able to see is the associated cluster. A 150mm scope shows a pretty collection of around 20 stars over a gentle glow. A 250mm scope doubles the resolved star count to 40 stars in an area roughly 20 arcminutes across. The integrated magnitude of the cluster is +7.2. ☐ **SEEN IT**

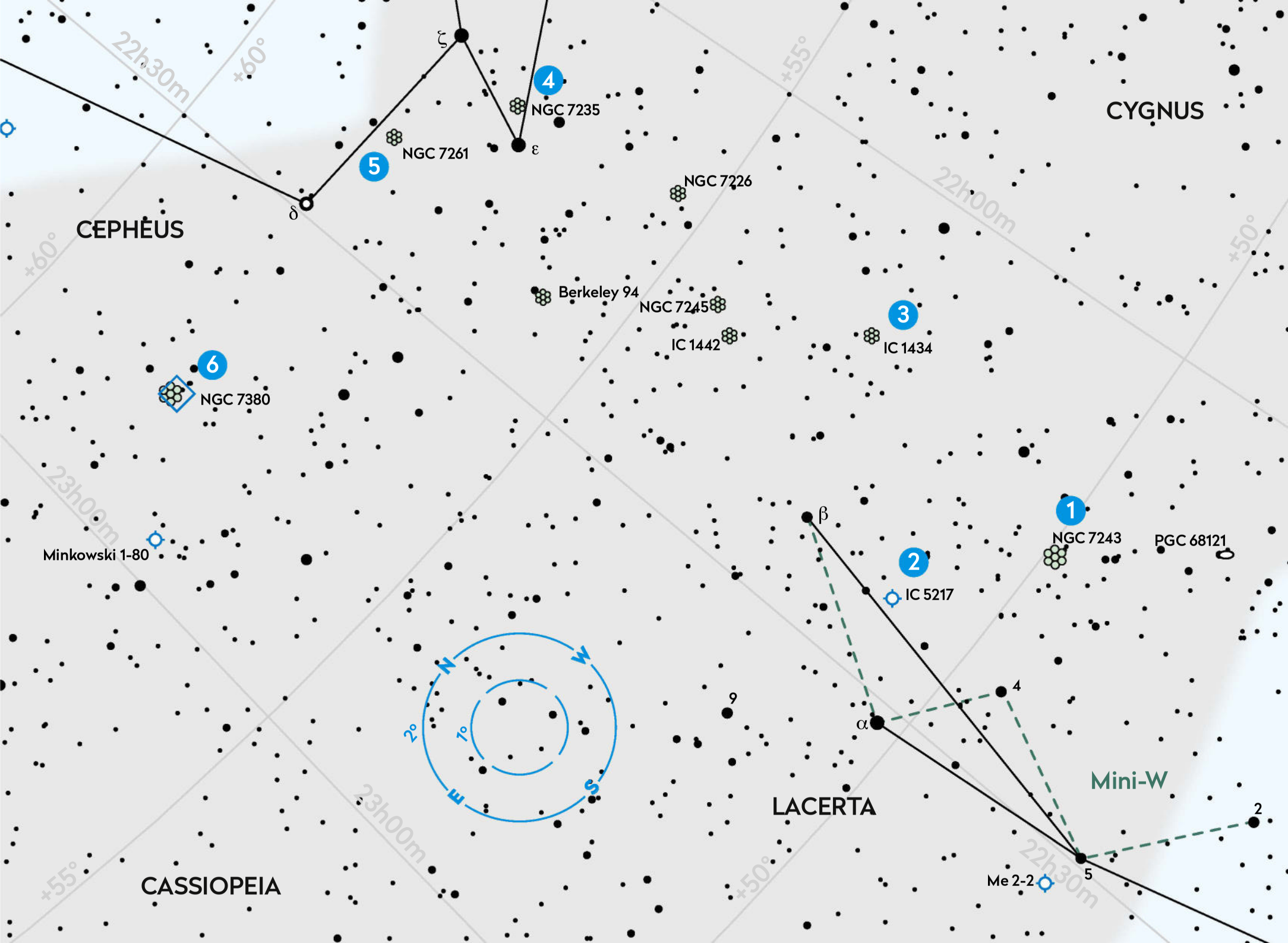
ROLF GEISSINGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions


CEPHEUS
CYGNUS
LACERTA
CASSIOPEIA
NGC 7235
NGC 7261
NGC 7226
Berkeley 94
NGC 7245
IC 1442
IC 1434
NGC 7380
Minkowski 1-80
NGC 7243
PGC 68121
IC 5217
Me 2-2
Mini-W
ζ
ε
δ
β
α
22h30m
22h00m
23h00m
+60°
+55°
+50°
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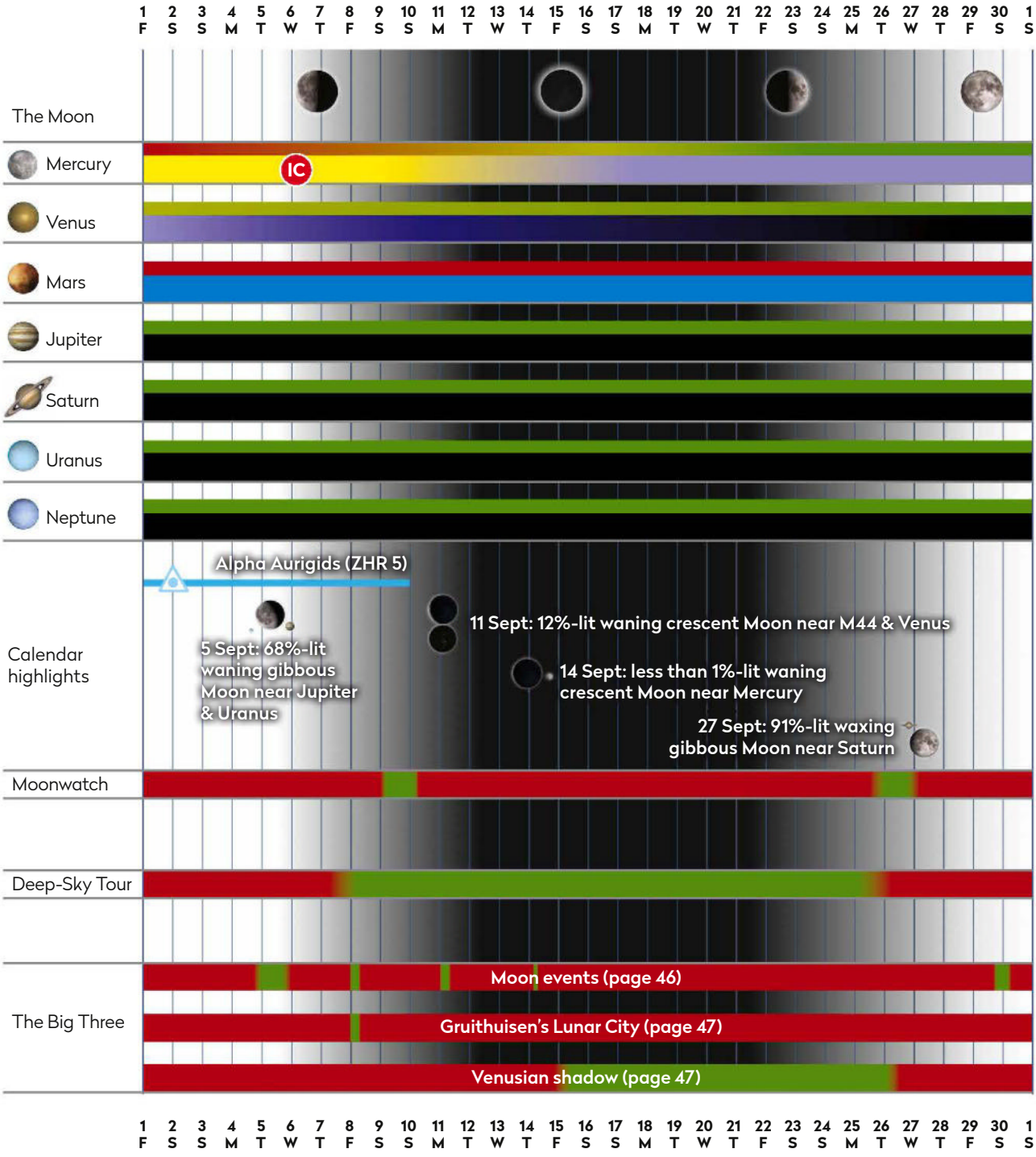
AT A GLANCE

How the Sky Guide events will appear in September



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

VALTTERI HIRVONEN

The Northern Lights never fail to enchant photographer Valtteri Hirvonen: "The end result is always a surprise"

Lights in the darkness

Photographing the aurora

Wilderness photographer **Valtteri Hirvonen** – who spends nearly half the year in darkness in his native Finland – reveals how he found new inspiration in the Northern Lights

Photography is not just my profession, it's also my hobby. In Finland, we spend nearly half the year in darkness, so during the winter months I wanted to find a way to continue pursuing photography in my personal time. Like so many other photographers, I had to find ways of working creatively with what is within reach, and that's what ultimately inspired me to shoot the night sky. Luckily, Finland is a great place for it. There are so many forests and amazing places where you have great visibility of the stars and, of course, wonderful displays of the aurora borealis, or Northern Lights.

Shooting the night sky makes you forget about time. On my work shoots there are usually a lot of people and a sense of hustle, but with astrophotography I am out in nature on my own, or with one other friend. ▶

▲ When the Sun barely rises for months, the Northern Lights bring magic to the long nights

▶ I love being in nature, especially at night. It's so silent and creates serene, peaceful moments.

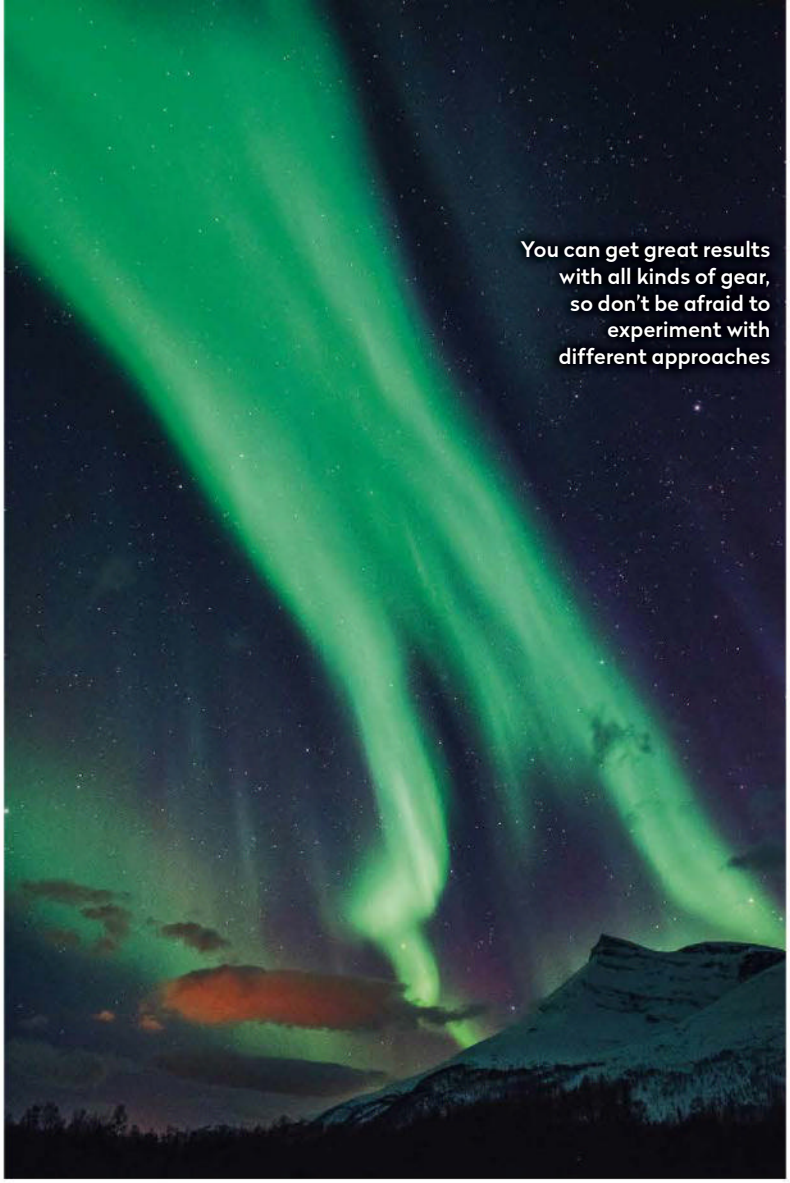
I also love that it forces you to be totally present in the moment. Living in Finland, I've seen the Northern Lights a number of times, but it never loses its charm. The appearance of the aurora all happens very fast, so you get a huge adrenaline rush, rushing to get the shot because it could well all be over within seconds. You also don't know how the images will turn out, because each display will reveal different colours, shapes and forms. That makes it all the better. When we shoot in darkness, we're shooting blind so the best thing about it is the fact that you're creating images you can't normally see with the naked eye. Only a camera can capture the long exposure, among other features, and that's what makes these moments magical – the end result is always a surprise.

ALL PICTURES: VALTTERI HIRVONEN

High-end kit not required

You might think photographing the aurora requires a lot of expensive gear and a lot of experience, but this is not necessarily the case. Some avid astrophotographers have a lot of gear to help capture really sharp photos, and they use apps to

▼ If you master the basics, you're free to enjoy and capture the moment when it really matters



You can get great results with all kinds of gear, so don't be afraid to experiment with different approaches

"It all happens very fast, so you get a huge adrenaline rush, rushing to get the shot because it could all be over within seconds"

track celestial objects or to receive aurora alerts telling them when and where the next big display will happen. However, I've shot a lot of astrophotography handheld. With today's technology, you can find a way to make it work most of the time. You just need a camera with full manual control and a lens with a wide aperture. Of course, the results of short, handheld captures and long-exposure shots taken with a tripod will look very different, but there is great creative potential in trying more artistic approaches. With a bit of movement in the shot, for example, you can almost paint with your camera.

And that's key. I love experimenting and trying to create something other than what you generally ▶

How to catch an aurora display

Valtteri's top tips for finding and photographing the Northern Lights

Although the solar winds that generate the appearance of aurorae on Earth can be predicted, and there are apps that can do just that, it's almost impossible to localise actual aurora displays. My advice is to go out with your camera and tripod and enjoy the moment in silence and darkness. If the sky is clear and you're in the Arctic region, you're more likely to see aurorae through your camera than to not see anything. You'll experience a wonderful starry night sky in any case, and aurorae will be a well-deserved bonus!

However, I do still check the Aurora Forecast app every once in a while (**www.tinacinc.com/AuroraForecast**). It shows live auroral activity, forecasts and sends push notifications to your device. **Aurora-alerts.uk** is a great resource for UK aurora-hunters, providing up-to-date information on solar activity as well as live aurora reports tailored to your location. **Spaceweatherlive.com** has detailed information on solar and auroral activity too.

When do you eventually see aurorae, you'll likely be capturing a green tint, so adjusting an image's tint will dramatically change how colours appear in the final edit. Clarity makes a huge difference. Just be cautious with the clarity slider, as it can also ruin your photo very easily and make it look artificial. And there's nothing wrong with a shaky image if the feeling is there! I've experimented a lot with handheld long exposures and been pleasantly surprised with the results. Do your own thing and break the rules. Paint with your camera, try the unexpected. Why couldn't your aurora photos be black and white? The most important thing is to embrace the moment.

▲ Apps like Aurora Forecast will help you find the aurora by tracking solar activity in real time and sending you alerts

When it comes to night shoots, "the feeling is what you should be following," says Valtteri

"There are unique astronomical moments everywhere – it's just knowing how to look for them and then capture them"

▲ Valtteri captured these light trails with the Milky Way behind while skateboarding through Utah's Zion National Park

▶ see scrolling through social media feeds. This could be shooting the Northern Lights in black and white or painting with an artificial light source. I've played around with having a light on my drone and using long exposures to create unusual light trails in the foreground of my images.

Plan for success

You can do astrophotography anywhere. Of course, there are pros and cons to any location. For example, if you live further south, you have the benefit of having a more consistent nightfall, which gives you the freedom to shoot all year round, while those of us in the Arctic regions are lucky enough to have the Northern Lights more often. But recent heightened solar activity is producing Northern Lights displays even in the southern parts of the UK. If you're interested in capturing an image of the aurora from the UK, it pays to keep a watch out for any alerts, and there are multiple websites and apps that will help you do just that. There are unique astronomical moments everywhere – it's just knowing how to look for them and then capture them.

Today's cameras are so good that they allow even amateur astrophotographers to capture professional-looking shots more easily. Even entry-level models are sensitive enough to capture the detail of the night sky. It's the same with handheld shooting: with

ALL PICTURES: VALTTERI HIRVONEN

Kit, composition, capture...

A quick guide to the gear, settings and techniques you'll need for imaging aurorae

▲ Valtteri's equipment, ready for adventure. It pays to have your kit packed so you can get going when aurora activity surges

Most people will say you need a nice, modern digital camera with good low-light capability, a wide lens and a tripod to get a good night shots, but I've experimented and come to the the conclusion that you can get great results with all kinds of gear. It'll just be different. For example, you *can* take long-exposure shots even with 20-second exposures just handheld. Sure, it'll be shaky, but you can turn it to your advantage.

But if you want to use more traditional methods, you won't go wrong with a wide-angle (16–35mm) lens and a tripod. Aurorae move and change very fast, so if you want to capture those crispy waves, bump up the ISO (as high as you need to, don't be afraid of it). If you've ever thought that, for example, ISO 6400 is the usable maximum, just try even higher settings. With modern cameras you might be pleasantly surprised! Try to keep the exposure shorter than 5 seconds. You can open up the aperture as much as you need to and just focus to infinity.

Composition-wise it's always good to have something in the foreground to give you scale, so consider the layout of trees, mountains and so on. The most important thing is to trust your instincts and just go for it. I've said it already but I'll say it again: the feeling is what you should be following. Everything else is just a bonus.

the image stabilisation in cameras now, you can get really sharp images. And with mirrorless cameras you have a lighter, more compact kit bag, which makes the experience much easier.

I say this for every genre of photography, but it really helps if you master the basic techniques, as it frees you to not have to think about it when it really matters. And it helps to know your surroundings. I usually go somewhere before it gets dark to wander around and figure out where the trees or foreground are. This helps me find different elements to create a beautiful shot when darkness falls. Give yourself the freedom to experiment – even the things people say you can't or shouldn't do, like shaking the camera. Trust your instincts and push your creativity to achieve new styles.

Valtteri Hirvonen is a Canon ambassador, and a videographer and photographer who lives in Helsinki, Finland

▼ Work out ahead of time what elements of your landscape will add even more drama to your night scene

OSIRIS-REx is due to arrive at Earth from asteroid Bennu on 24 September 2023

NASA'S GODDARD SPACE FLIGHT CENTER CONCEPTUAL IMAGE LAB, NASA'S GODDARD SPACE FLIGHT CENTER

The rock hunter RETURNS

As OSIRIS-REx becomes the latest spacecraft to bring back samples from another world, **Ezzy Pearson** examines how these missions help reveal our Solar System's history

ILLUSTRATION

On 24 September, NASA's OSIRIS-REx mission will finally arrive home, the culmination of its seven-year-long journey to asteroid Bennu and back. The Origins Spectral Interpretation Resource Identification and Security – Regolith Explorer, to give OSIRIS-REx its full title, will be carrying with it an estimated 250g of dust and pebbles which it carefully gathered from the asteroid's surface back in October 2020.

This precious cargo is being eagerly anticipated by planetary geologists around the globe, as it will be one of just a handful of pristine samples taken directly from another Solar System body. That may not be the case for long, though. Recent years have seen the number of such sample-return missions increase, heralding a new age for this particular field of space science.

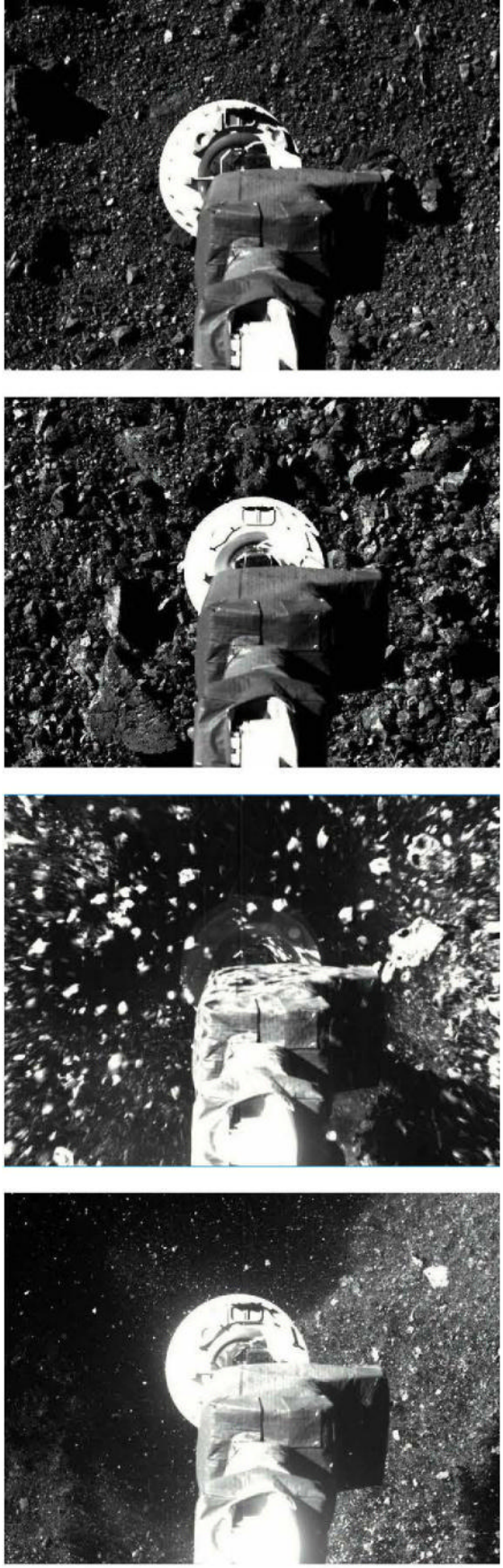
These missions provide a hugely important piece in the puzzle of understanding our Solar System's history. Four and a half billion years after its creation, our Solar System is still littered with the remnants of planets that never came to be, in the form of comets and asteroids like Bennu. Astronomers have spent centuries staring at these distant objects, while more recently orbiters and lander missions have offered a closer look. To really understand these space rocks, however, requires the use of advanced equipment that can only be found in labs here on Earth.

Snippets of the Solar System

We have long been able, of course, to look at pieces of some asteroids that have obligingly fallen to Earth as meteorites. For decades, these have been collected, catalogued and studied to give us our current picture of the disparate worlds of our Solar System. The problem is that as soon as a meteorite enters Earth's atmosphere it's contaminated by our environment, which limits its usefulness as a source of information. Additionally, unless the meteor was seen streaking through the sky, there's usually no indication as to exactly where in space these rocks have spent the last four billion years before hitting Earth.

"My background is in geology, and one of the things our lecturers always say is it's so important to do fieldwork," says Sara Russell, head of planetary materials at the Natural History Museum. "You don't just analyse a rock; you have to know what all the rocks around it were, where it came from, what the environment was like."

This is why a growing number of space agencies are working on sample-return missions, of which OSIRIS-REx is merely the most recent. The first



▲ **Hit the rocks: OSIRIS-REx's robotic arm snatches its sample in just six seconds of contact in October 2020**

such missions were the Apollo landings, which in total returned an astounding 382kg of Moon rocks. Here, the fieldwork was done by human astronauts who took detailed observations and records of the landscape as they went.

However, most sample-return missions have been robotic. The earliest of these were the Soviet Union's Luna 16, 20 and 24, which between them returned around 300g of material in the '70s, but ▶

NASA X 2, JAPAN AEROSPACE EXPLORATION AGENCY X 2, CNSA, JAXA, NASA/JPL-CALTECH

▲ **Apollo 14's Edgar Mitchell, Stuart Roosa and Alan Shepard are shown lunar samples gathered during their mission**

▶ their primitive cameras and sensors provided only limited context. It's taken 50 years for technology to develop to the point where spacecraft can operate as effective field geologists.

This fieldwork is started as soon as the spacecraft are within sight of their intended target. When Japanese sample-return mission Hayabusa2 arrived at asteroid Ryugu in June 2018, it spent several months examining every part of the asteroid with its cameras. Six months later, OSIRIS-REx began its own observations when it arrived at Bennu.

"From that you can look at boulder size, distribution and shape," explains Russell. Specialised spectral cameras can even give some indication as to what minerals the rocks are made of. "So you can see whether the bodies are made of the same thing, or if there's a variety of different rocks."

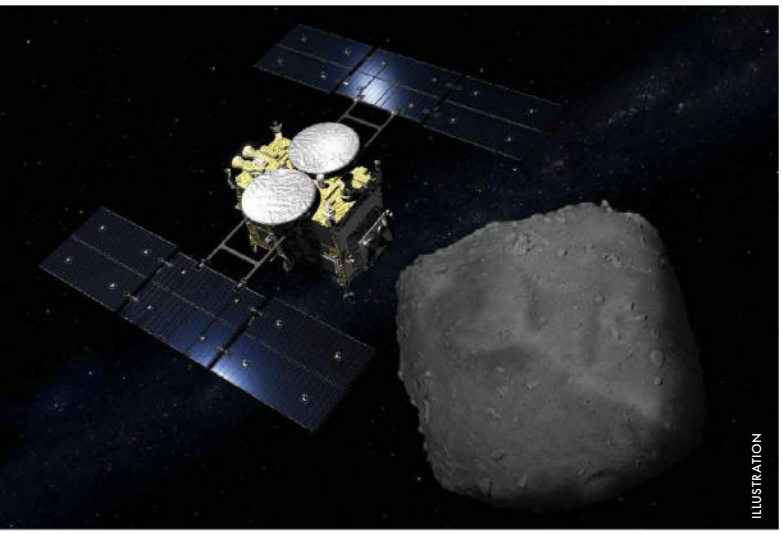
These measurements are a vital part of the mission. For OSIRIS-REx, they fulfil the 'Resource Identification' part of its moniker by helping to analyse what potentially useful compounds and minerals can be found on asteroids, which could be mined by future space explorers. They also provide important context that geologists will call upon later. More immediately, they help the flight team pick out the ideal site to take their sample from.

"The engineers always insist you pick the safest place," says Russell, "but the scientists want you to pick somewhere that's scientifically interesting. In OSIRIS-REx's case, they picked a dark area because that might have more organic material in it."

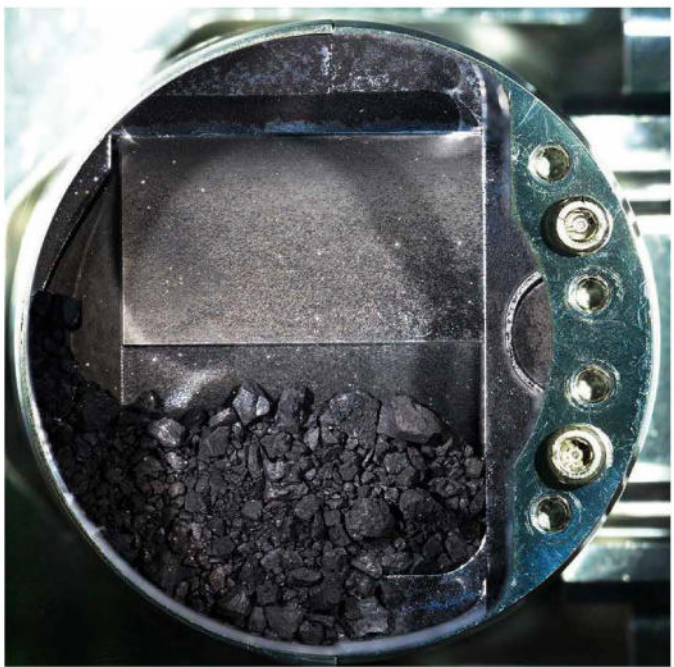
Rock of ages

Organic materials are the carbon-based chemicals which form the building blocks of life. It's thought that asteroids were responsible for bringing these chemicals to the early Earth.

"We know that meteorites collected here on Earth contain a whole zoo of organic materials," says Russell. The problem is, Earth is even richer with organic materials, which meteorites come into contact with as soon as they enter our atmosphere.



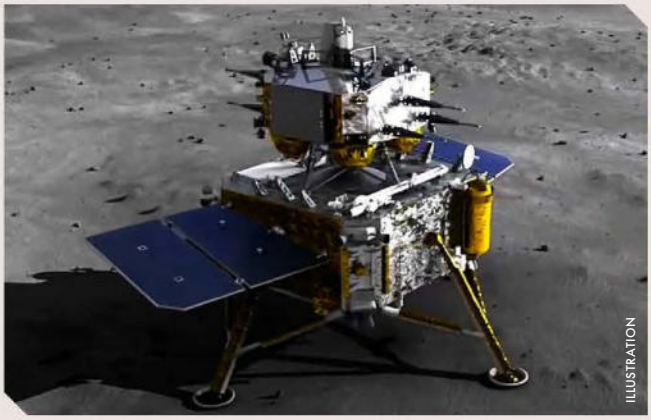
ILLUSTRATION



▼ **Hayabusa2 (left), Japan's six-year mission to asteroid Ryugu, returned a 5.4g sample in December 2020 (right)**

Future missions

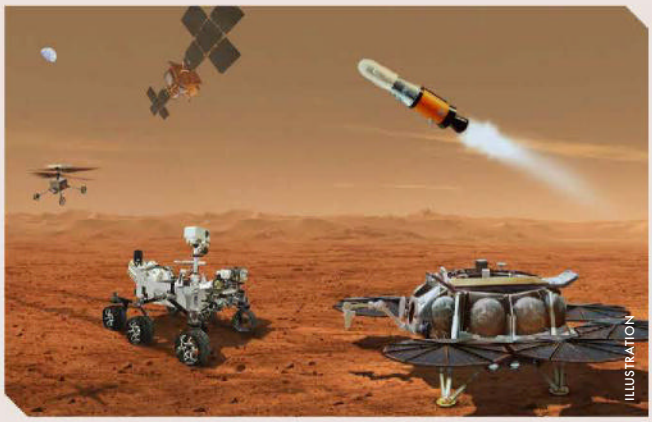
A slew of sample-return missions are set to launch in the coming decade



Chang'e 6, CNSA, 2024
China aims to collect 2kg of material from the Moon's far side, a region from which we have no samples. The lander can collect material up to 2m down, where it should be protected from solar and cosmic radiation. The craft was originally a back-up to Chang'e 5, which returned a nearside sample in 2020.

Martian Moons eXploration (MMX), JAXA, 2024
Following Hayabusa2's success, Japan is looking further afield to Mars's tiny moon, Phobos. MMX will spend several months conducting a detailed study of Phobos before collecting up to 10g of material. After making several fly-bys of the smaller moon, Deimos, it will head back to Earth, arriving in 2029.

Artemis III, NASA, 2026
The first of many planned human missions to the Moon is bound for the lunar south pole, where NASA hopes to set up a permanent base. Samples taken by the crew and other support missions will be analysed not just for their scientific value but for any resources that future Moon-dwellers could use.



Mars Sample Return, NASA/ESA, 2030s
Since 2021, NASA's Perseverance rover has been collecting dozens of samples from the Martian surface. NASA and ESA are planning a pair of follow-up missions to collect them: a surface lander to gather the tubes and launch them into orbit, and an orbiter to catch them and return them to Earth in around 2033.

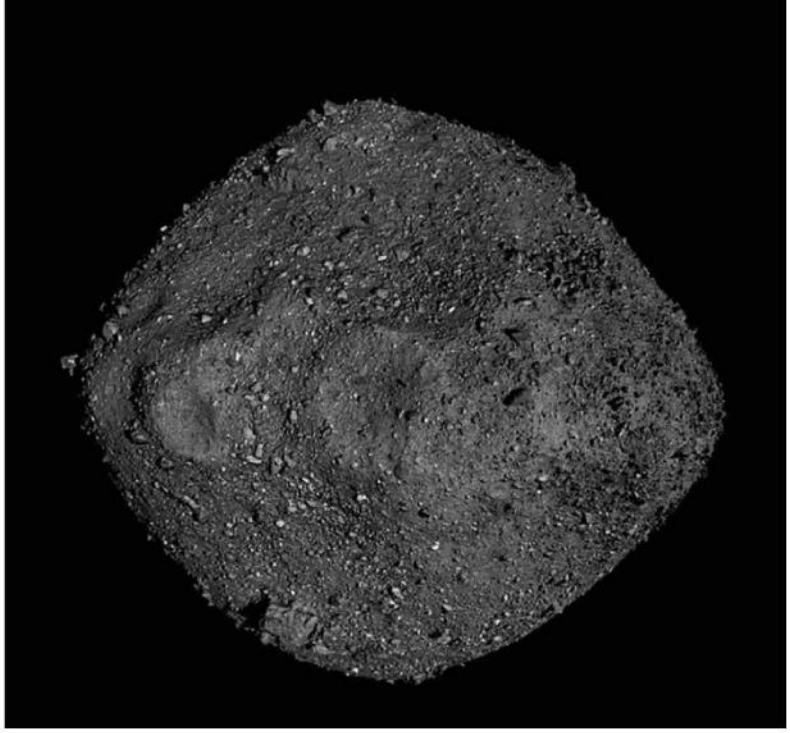
"There's a lot of controversy about which of these are due to contamination and which are indigenous."

Keeping the sample free from contamination is a prime concern, so as soon as the sample is taken it's sealed inside a special return capsule for the journey back to Earth. As well as protecting the sample from Earth's biology, the capsule insulates the precious space dust so it remains at a stable temperature even through the scorching heat of re-entry.

"Most sample returns come from places that have not been hot for billions of years," explains Russell. "We don't want them to start having chemical reactions or similar, so keeping them cool is really important. And also challenging when you're dropping them from space!"

The returning capsules are normally directed to land in deserts, as these are largely unpopulated regions with few obstacles that could damage them. Soon after arrival, they are swarmed by waiting collection teams that gather not just the capsule but also 'witness samples' of the surrounding air and soil. These – along with special plates which were in the room alongside the spacecraft when it was initially being built – help guide those looking at the samples by recording possible contaminants.

The capsule is then transported to a dedicated facility – the Johnson Space Center in Houston in the case of OSIRIS-REx – where it will be placed in a sealed box filled with inert hydrogen gas that will prevent terrestrial air from getting into the sample. ▶



NASA/GODDARD/UNIVERSITY OF ARIZONA, NASA, NASA/JPL-CALTECH/MSSS, ASSOCIATED PRESS/ALAMY STOCK PHOTO JOE VELLA/ALAMY STOCK PHOTO

▲ **Thought to be a 4.5-billion-year-old remnant of the early Solar System, Bennu could help reveal how planets formed and life emerged on Earth**

▶ "Trying to make sure the sample doesn't come into contact with the atmosphere is the absolute biggest thing," Russell emphasises. "That means keeping it away from oxygen and water, because those are things that will react with the sample and make it start to erode away."

Once the canister is open, the team will photograph every pebble and grain collected to catalogue what they have. Around 75 per cent of the sample will be packaged up and stored, ready for future generations of researchers to analyse, but the remaining quarter will be divided up and sent to waiting partner facilities around the world.

"We're really lucky to be getting a bit of Bennu very early on," enthuses Russell. "We're going to CT scan it – which is largely considered non-destructive – and that will give us an idea of its internal structure."

Scientific smash and grab

Alas, many of the tests will not be so kind to the sample. OSIRIS-REx is expected to collect some pebbles up to 2cm in diameter, which can be sliced up and polished so they can be looked at under an electron microscope, which gives a close-up view of the physical and chemical structure of a rock. Other tests will use lasers to precision burn parts of the sample, sniffing out the elements released in the smoke.

In fact, all around the world, teams of planetary geologists will be taking these carefully collected samples and then cutting them up, smashing them to pieces, burning them, even dissolving them in acid. But when the data from all these tests is put together, it will give us a full picture of what the asteroid is made from and how it was all structured. As we know the conditions needed for certain minerals to form, or what has to happen for a particular crystal structure to arise, all this information will help us to understand that particular asteroid's history, leading to what we see today.

Once we have that knowledge, it will be time to unleash the real power of returned samples,

▼ **The Bennu sample will be put through exhaustive tests at NASA's Johnson Space Center and other institutes**

Protecting Earth

Space rocks contaminating our planet is as perilous as the other way around

It's the premise of many sci-fi tales, but the threat of bringing back some alien microbe that could harm our planet is something all space agencies take very seriously. Billions of years of being bombarded with cosmic radiation have rendered asteroids safely sterile – but that's not the case on Mars.

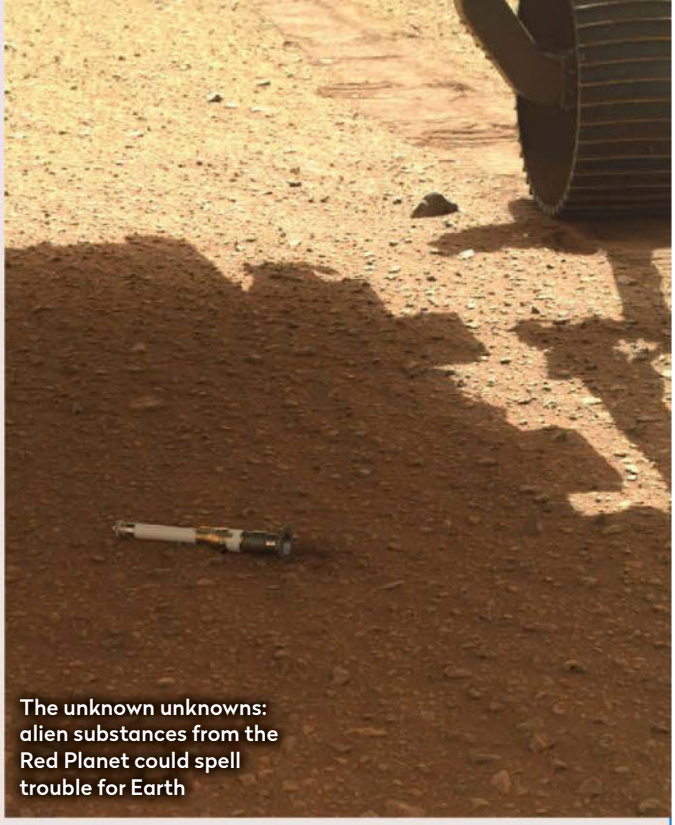
"Though we have seen no evidence for life on the Red Planet so far, it would be naïve to assume there isn't any, given it's a planet with an atmosphere," says Sara Russell.

The Perseverance rover is currently collecting a series of samples on Mars, which NASA and ESA hope to return to Earth some time in the next decade. Already there are plans for what precautions are needed to keep Earth safe.

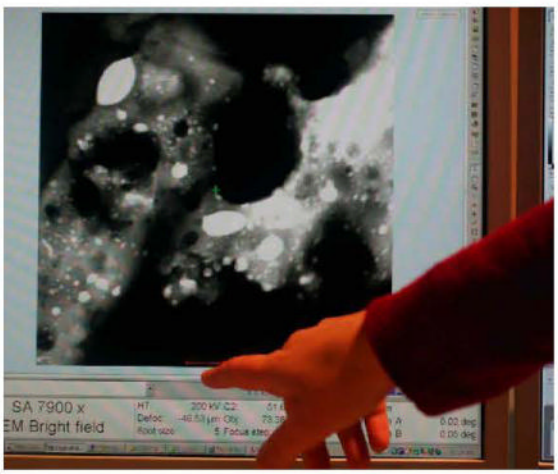
"The first samples will be taken to the US, who have taken on that responsibility," says Russell. "They'll be kept in BSL-4 biocontainment, the same level that's used to look at Ebola viruses, and will be absolutely assumed to be as dangerous until proved otherwise."

While the samples are under containment, the team will conduct tests to look for evidence of Martian biology. After this, the rocks will be bathed in gamma radiation to sterilise them without affecting their bulk chemistry or mineralogy.

"We've learned from old voyages of discovery, when Europeans explored the new world and took lots of horrible diseases with them," Russell concludes. "This is something that we have to be super-aware of, and careful not to make mistakes that we've made before."



The unknown unknowns: alien substances from the Red Planet could spell trouble for Earth



▲ Magnified particle samples retrieved from the coma of comet Wild 2 by the Stardust mission in 2004

▲ A slice of the Imilac meteorite found in the Atacama Desert in 1822 and held by the Natural History Museum

which comes not from what they look like in and of themselves, but from how they compare with what we already have. Currently, we only have direct samples from three asteroids, our Moon and a comet's tail as collected by Stardust in 2004, which is hardly a full representation of the variety that we see across the Solar System. For that, we have to turn to the vast meteorite collections at the Natural History Museum and other institutes around the world. The handful of samples taken directly from source give a vital insight to peel away at least some of the uncertainties surrounding meteorites.

"Hayabusa2's Ryugu sample looks like most chondrite meteorites," says Russell. "These are made of chondrules – tiny round blobs we think came from our protoplanetary disc. So they're frozen samples of what was there before the planets. Around eight per cent of meteorites that fall to Earth are chondrites."

There is one big difference between Earth-collected chondrites and the Ryugu sample, however. "Chondrites contain 20 per cent water, Ryugu contained 10 per cent water. The meteorites have soaked up water from the atmosphere which the sample return hadn't."

Perhaps even more exciting is the prospect that sample-return missions can visit places not represented by meteorites. Early indications suggest that Bennu could be unlike anything we have on record. With several more sample-return missions expected in the next few years, who knows what other worlds we could soon have a piece of, back here on Earth?

Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is available through History Press

The fundamentals of astronomy for beginners

EXPLAINER

Star-hopping

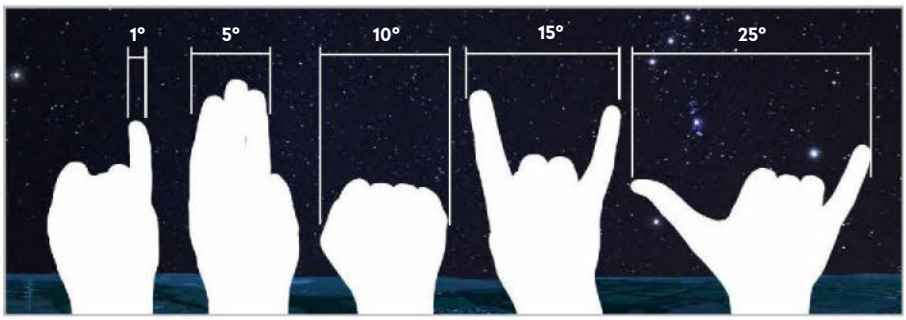
Steve Tonkin explains an easy technique to navigate your way around the night sky

If you're a newcomer to the wonderful hobby of astronomy, your first time under a clear sky can be an overwhelming experience. How will you ever find your way around this vast number of stars?

Fortunately, there's a tried and tested method, developed over millennia, to turn this bewildering confusion of bright dots into a familiar recreation ground, and which works in bright and dark skies alike. It's called star-hopping.

What we do is make easily identifiable patterns (called asterisms) from the brightest stars and use these as jumping-off points to locate our desired target objects, and we estimate directions in relation to other stars – for example, "towards that bright yellowish star".

Estimating distances works in much the same way – for example "a third of the way from the lower star to the upper one" or a proportion of the field of view of your binoculars or telescope. Alternatively, if you stretch out your arm, you can use the distance covered by your fist or handspan to measure out the distance (most of us are more or less similarly proportioned for this purpose). Let's look at four star-hops to help test your skills.



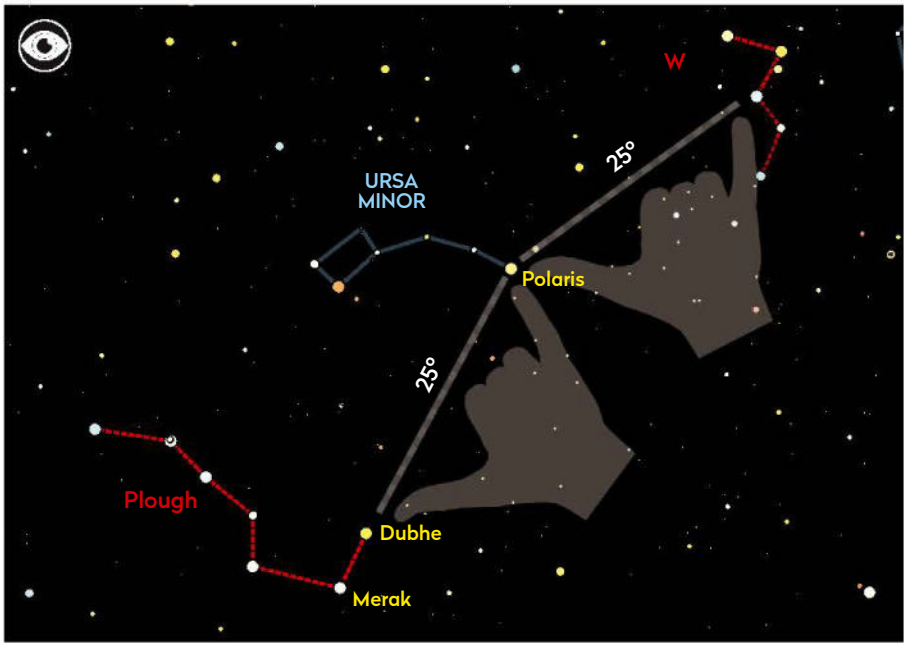
▲ **With your arm outstretched, use your hand to gauge distances between objects in the sky**

Stephen Tonkin is an experienced binocular astronomer, who writes our monthly Binocular Tour

Star-hop your way to the Pole Star

Polaris is crucial in astronomy, because it marks the position of the North Celestial Pole, the point around which the northern sky seems to revolve, and which is above the north point on the horizon – so that's where we'll begin. We'll use 'the pointers', Merak and Dubhe, in the Plough asterism of Ursa Major. These point directly to the pole star, Polaris, which is slightly more than a hand-span from Dubhe – or, if you prefer, about five times the distance between Merak and Dubhe.

Sometimes, during autumn evenings for example, the Plough may be close to the horizon and concealed by trees or buildings. In that case, the W-shaped asterism of Cassiopeia will be high in the sky and we can use that instead.

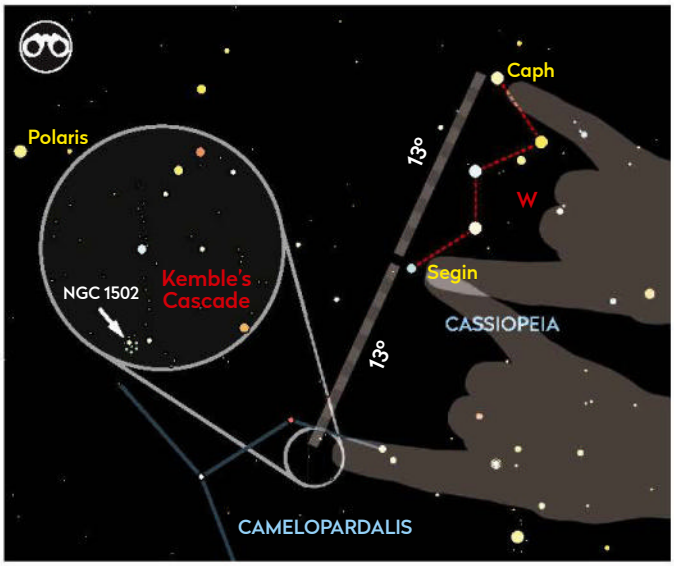


▶ **Polaris is an easy hop, one hand-span away from the unmistakable Plough**

CHARTS BY PETE LAWRENCE

Hop to the asterism Kemble's Cascade

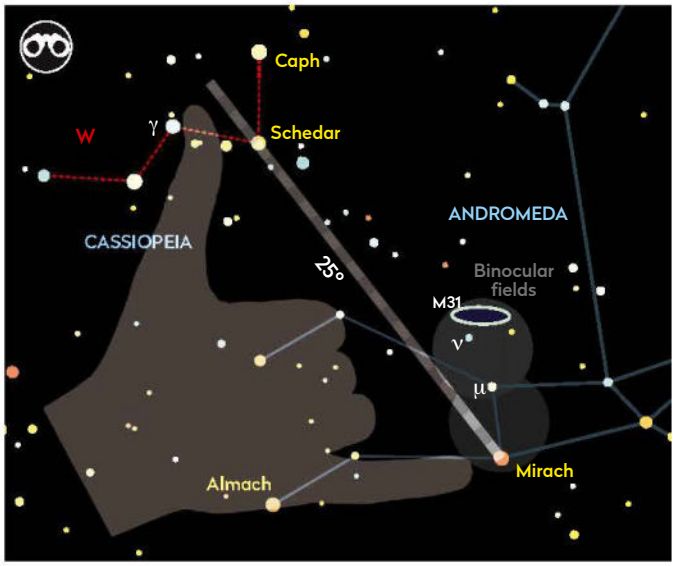
Finding Kemble's Cascade in Camelopardalis with binoculars requires a long star-hop, as there are no nearby bright stars. Find Caph and Segin at either end of the 'W' shape of Cassiopeia. Use the little finger and index finger of one hand to measure the distance between them. Then, without changing the distance between your fingers, locate the point in the sky that's the same distance the other side of Segin in a straight line from Segin and Caph. Keeping your eyes fixed on this point, raise your binoculars and you should see a straight line of eighth and ninth-magnitude stars with a bright mag. +5.0 one in the middle. On autumn evenings it's almost vertical, resembling a ribbon waterfall cascading into the 'splash-pool' of the open cluster NGC 1502.



▲ To get to Kemble's Cascade, measure the distance between the points of Cassiopeia's 'W', then hop on by the same distance again

Hop to the Andromeda Galaxy, M31

The easiest way to find the Andromeda Galaxy, M31, is a two-part star-hop. The first hop locates the star mag. +2.1 Mirach in the constellation of Andromeda, from which we do a second hop. Locate the 'V' of stars made by Caph, Schedar and Gamma Cassiopeiae. Follow the arrow these make to Mirach, around a hand-span away. Now locate Mirach in binoculars: it's distinctly yellow, so is easy to identify. Put it near the southeast edge of your field of view (near the bottom during autumn evenings) and look for the white, mag. +3.9 Mu Andromedae near the other side. Now put Mu where Mirach was and you'll see a fuzzy patch where Mu was. This is the light that has arrived in your eyes 2.5 million years after it left the Andromeda Galaxy.

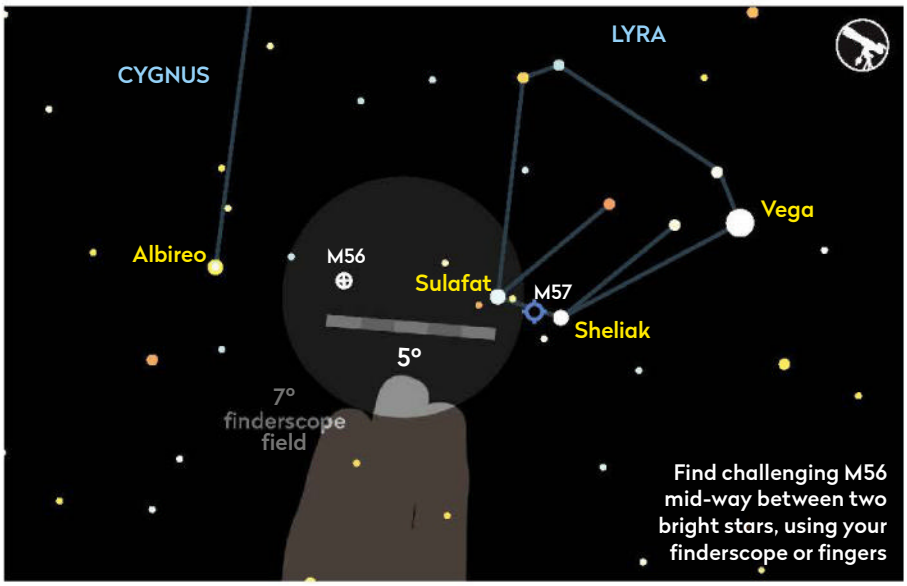


▲ Using your binoculars' field of view as your benchmark, hop from Mirach to Mu, then pivot that same distance to hop from Mu to M31

...and to the globular cluster M56

At mag. +8.4 and only 5 arcminutes in diameter, M56 is a little faint and small for binoculars, so we'll change to a telescope. To find it, first identify mag. +3.1 Albireo, the head of Cygnus, the Swan, and mag. + 3.3 Sulafat in Lyra. M56 lies directly between them, 4.5° from Sulafat.

If your telescope has a finderscope, you can relate this distance to its field of view (a typical 6x30 finder is 7°). Otherwise, you can use the apparent width of your three middle fingers, which is roughly the same as 4.5°. With a low-power eyepiece in the telescope, use your finder to put you in approximately the right position. You should be able to see M56 looking like a defocused star in the telescope eyepiece. Centre it and swap to a higher-power eyepiece to get more detail.



Find challenging M56 mid-way between two bright stars, using your finderscope or fingers

FAMILY FRIENDLY PROJECT

DIY ASTRONOMY

Make a Solar System diorama

An easy, fun craft project to learn about our neighbouring planets

Mary McIntyre is an astronomy educator and teacher of astrophotography

This project takes a few simple materials and turns them into a stunning space scene, while providing numerous learning opportunities for the whole family.

The diorama isn't intended to provide any kind of correct scale in terms of the sizes of the planets or the distances between them, although we still chose different-sized polystyrene balls to give an overall impression of their relative sizes. You can use any size of balls for your planets, but make sure that they'll all fit in your box. We hung our planets in the correct order, but at different heights and depths – be as creative as you like. In ours, Saturn is hanging at an angle, although this was purely to save space!

▲ **Get creative! Paint your planets then add comets, stars, nebulae, space ships or whatever you like to your space scene**

Craft your cosmos

Before painting the box, remove or cover any shiny tape. We also lined the base of the box with a sheet of heavy-duty brown paper. This covered the flaps and gave a smoother back to our diorama. Painting the background is a fun, creative process that allows you to make a space scene in whatever style you like. We included nebula clouds, galaxies and stars, but you can use different colours, add comets, or even some fairy lights!

There was no space for a large hanging Sun in our box, so instead we drew onto a flat disc and stuck it onto the inside-left panel. Making this provides good practice at drawing sunspots. Each of the planets is hand-painted using reference images from the internet. Because Venus is obscured by thick clouds, we used a photo that showed surface features that were captured by radar. A quick internet search will provide you with a rotating projection of each planet. To keep each ball secure during painting, we pushed them onto a cocktail stick held up by a clothes peg. If you can't find polystyrene balls, you can paint each side of the planets onto flat discs of card instead.

Saturn's rings were made by cutting a circle of craft foam (or use white card) and affixing it to the planet with PVA glue. While the planets are being painted, you can teach the family about the features and explain why the planets all look so different. Our diorama contains an asteroid belt made from seed beads and black thread. This is an opportunity to talk about where the asteroid belt lies and why it exists.

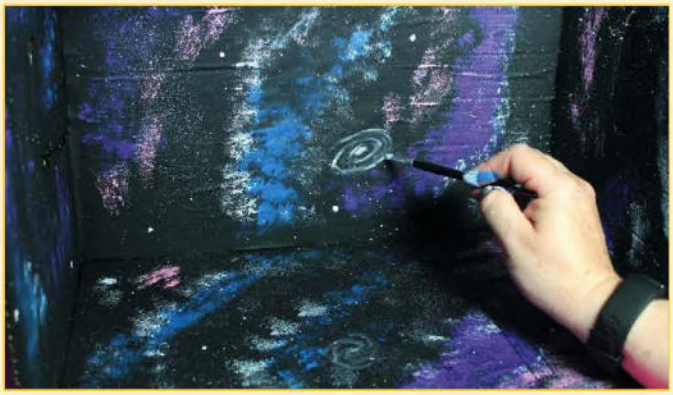
Having this diorama on display will provide repeated chances for everyone in the family to see the planets and memorise their key features and their order within our Solar System.

What you'll need

- A sturdy cardboard box. Ours measured 38cm x 29cm and we trimmed the depth to 25cm
- Polystyrene balls for the planets. We used 1 x 2cm, 3 x 3cm and 4 x 5cm
- Acrylic paints for painting the box, nebulae, planets, galaxies and stars
- Brush-tipped pens and pencils for the fine details
- Yellow/orange card for the Sun; white/grey card or craft foam for Saturn's rings
- Seed beads and thread to create the asteroid belt. We used white beads and black thread
- Ribbon or strips of black card to give the box edges a neat finish
- Sticky tape, PVA glue

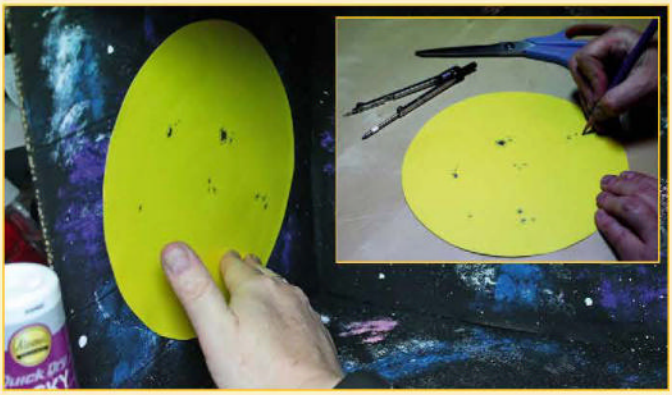
ALL PICTURES: MARY MCINTYRE

Step by step



Step 1

Paint the entire box with black acrylic paint. Once dry, use the coloured paints and a sponge to create nebula clouds, then add stars by flicking white paint off a toothbrush. Finally, use white paint and a small brush to paint background galaxies.

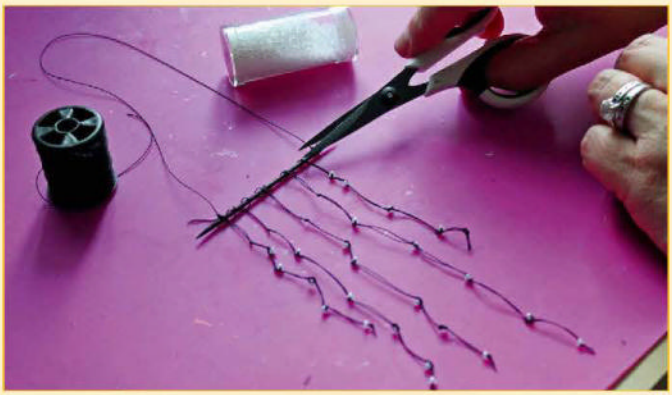


Step 2

Make the Sun by cutting a circle out of yellow or orange card. For ours we cut a circle with a diameter of 25cm. Draw some sunspots using a pencil, making sure you show the umbra and penumbra regions. Stick the disc to the inside left panel of the box.

Step 3

Paint each planet. Start with a base coat of acrylic paint then add features with pencils and brush-tipped pens. For Saturn's rings, cut an 11cm circle from craft foam with a 5cm hole in the middle. Add black bands to mimic ring gaps, then glue it to your Saturn.



Step 4

Make the asteroid belt by knotting a few white seed beads along strands of black thread. We made five strings, attached them to a cocktail stick that we'd painted black and added a large loop attached to each end of the stick to hang it with.

Step 5

Using a long needle, thread each planet with a double strand of black thread. We used a black seed bead to secure the bottom. Hang the planets and the asteroid belt from the top of your box, in the correct order, knotting the threads to secure them.

Step 6

Glue strips of ribbon or card along the front edges of your box using hot glue. We used a ribbon that had a complementary nebula design, but you could use black. This will hide any raw edges and give your diorama a nice, tidy finish.

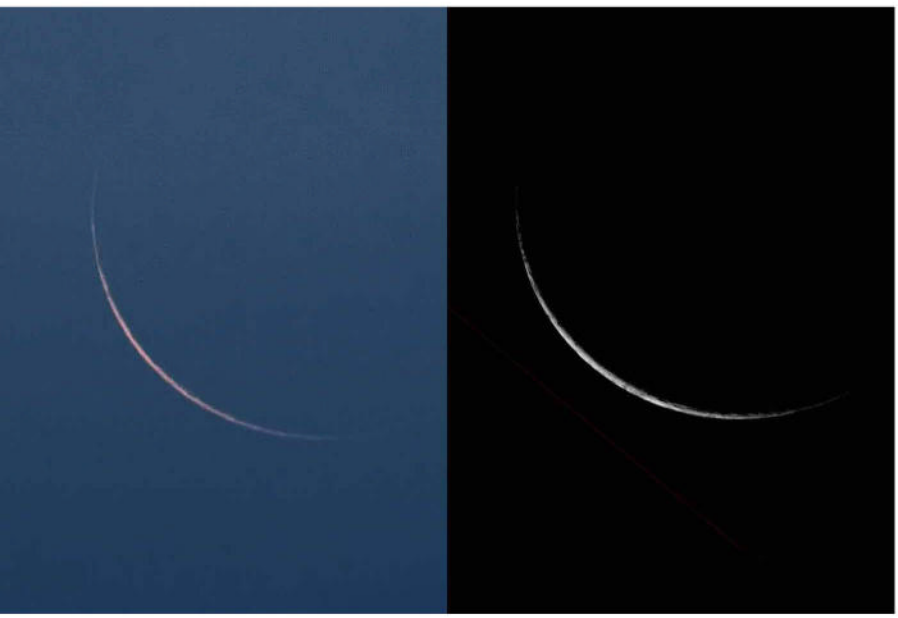
Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY

CAPTURE

Imaging thin Moons

Thin Moons are tricky to find and photograph. We show you how to catch a captivating crescent



▲ **Two different thin Moon crescents captured with a DSLR (left) and a mono high-frame-rate camera fitted with an infrared pass filter (right)**

Lunar imaging is generally one of the less demanding parts of astrophotography – the Moon is bright, with lots of contrasting features for accurate focus and its brilliance in the night sky makes it fairly easy to locate with a camera. However, not all Moon phases are alike, and one in particular will push your imaging skills to the limit: the thin Moon.

A thin Moon is the very thin crescent phase you get just before and after new Moon. Visibility of such crescents depends on several aspects, including weather, timing and date. Let's take these in turn.

Weather is fairly obvious because if it's cloudy the Moon will be hidden. However, as thin Moons lack the brilliance and contrast of a regular-phase Moon, even haze or thin cloud can easily obscure them. As they are relatively close to the Sun, waiting for the sky to darken sufficiently to see them means the Moon's altitude will be low. This naturally places the Moon in a region of sky that is always hazy.

This is heavily affected by the date when you're viewing, as we'll explain shortly. However, another aspect of timing concerns when the thin Moon becomes visible. In order to stand even a chance of seeing a thin Moon, you'll need to try outside of the Danjon limit, the smallest separation between the thin Moon and the Sun that the former can be visible. A Moon closer to the Sun than the Danjon limit isn't normally visible because there's not enough illuminated surface to be seen. The Danjon limit is around 7°.

Each day the Moon moves an average of 12° against the background stars. Poor timing may therefore result in an old (before new) crescent or young (after new) crescent being too close to the Sun to be seen. In addition, a well-timed old crescent in the spring or a well-timed new crescent in the autumn will typically not be seen because of the time of year. This is the all-important date or seasonal aspect.

The Moon's orbit is inclined to the ecliptic by around 5°. This means the visibility of thin crescents is heavily influenced by the inclination of the ecliptic to the horizon at sunrise or sunset. In the spring, the morning (sunrise) ecliptic is shallow to the eastern horizon and the evening (sunset) ecliptic angle is steep to the western horizon. In the autumn, the opposite is true, with the morning ecliptic being steep and evening ecliptic being shallow. A steep angle gives a thin Moon better visibility than a shallow angle. Consequently, during the spring it's evening thin Moons that are easiest to see, while during the autumn it's the morning ones that are favourable.

On the morning of 14 September, the Moon's orbital tilt places it 3° north of the ecliptic. Just before sunrise this means the Moon will appear vertically above the Sun's position. With a separation of 8.9° from the Sun (centre to centre), this is an ideal opportunity to catch this tricky but rewarding sight.

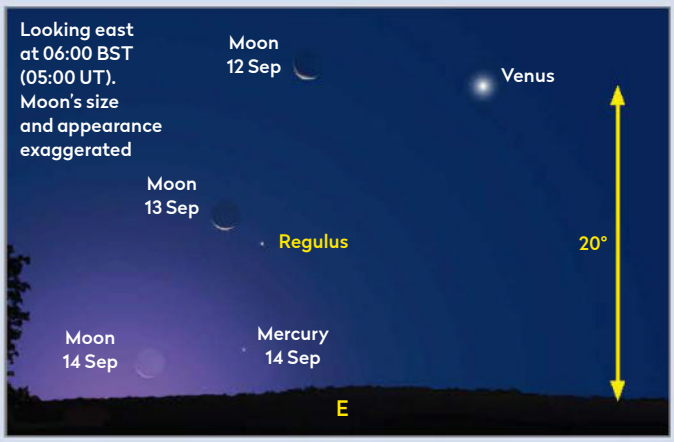
Equipment: DSLR or equivalent, telephoto lens or telescope, driven equatorial mount (optional)

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step



STEP 1

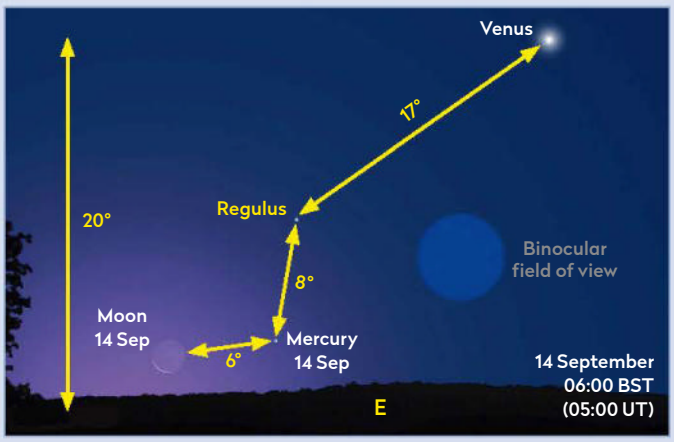
Having clear conditions for the thin Moon on the morning of 14 September will be down to luck. Build up to it by capturing the equally well-placed morning Moons from last-quarter on the morning of 7 September through to the 14th. This will give you a feel for the capture and where the thin Moon will be located.

STEP 2

Use any camera capable of capturing the Moon. A DSLR fitted with a telephoto lens or attached to a telescope is particularly good for the interactive adjustment of settings required. A tracking mount isn't necessary but is convenient. A high-frame-rate (HFR) camera fitted to a telescope can work well too.

STEP 3

If you use a colour HFR camera, an atmospheric distortion corrector will reduce colour fringing caused by light passing through the thick atmosphere at low altitude. A mono HFR camera with good infrared sensitivity and fitted with an infrared pass filter is ideal as it naturally darkens the surrounding sky.

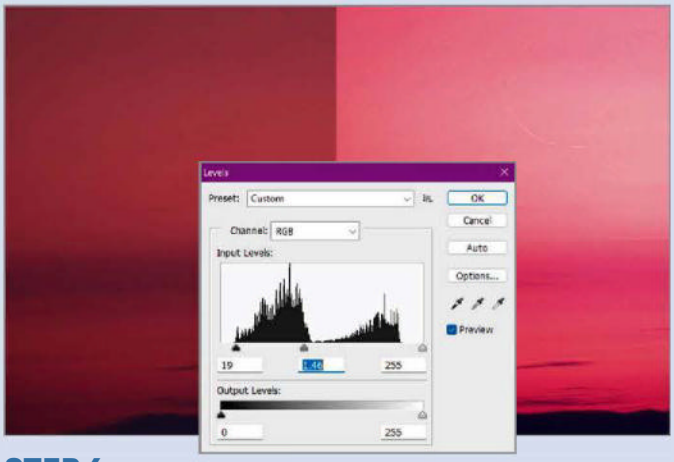


STEP 4

Use the mornings before 14 September to work out the Moon's location when thinnest. Make sure the view in this direction is clear of obstruction. Bright Venus, Regulus (Alpha Leonis) and Mercury can be used as locators. Extending the Venus–Regulus line for two-thirds that distance again gives you the general area.

STEP 5

On the run-up to 14 September, establish your setup in terms of imaging scale. Consider whether the horizon should be in the shot. If using a HFR camera, will you do a single capture or mosaic together several shots? Test your setup, making notes on the correct exposure for the Moon as sunrise approaches.



STEP 6

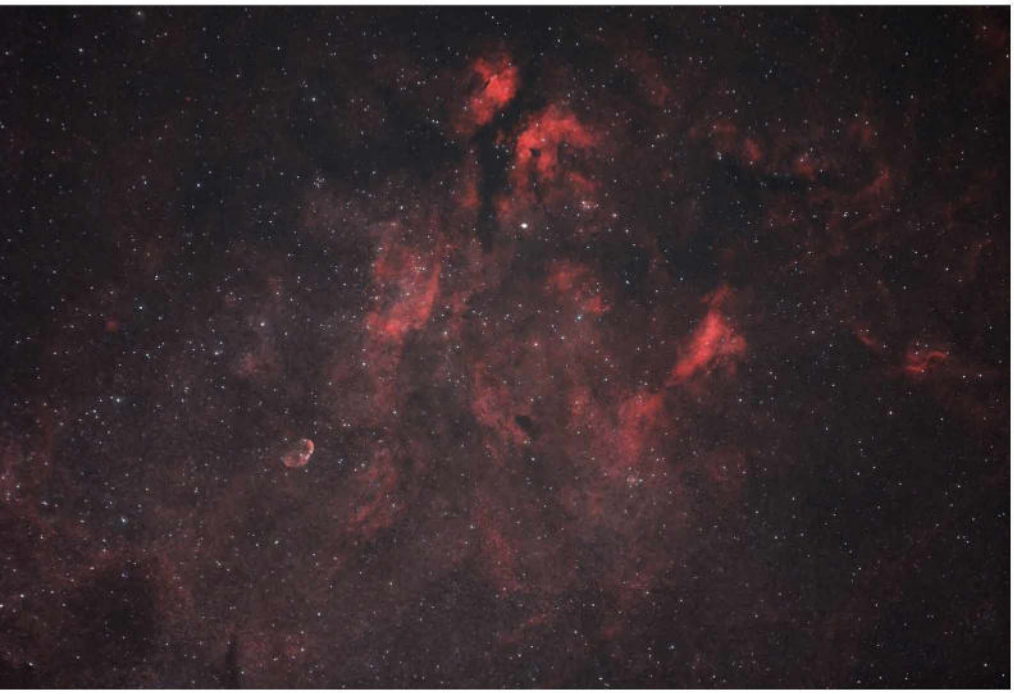
On 14 September, use Venus for focusing and alignment. Mercury lies half the Venus–Regulus separation below and left of Regulus. The Moon is 75 per cent the Regulus–Mercury separation left and slightly below Mercury. If the thin Moon isn't apparent, take many shots at varying exposures; processing may reveal the crescent.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Mastering flats

Adding DSLR flat frames to your workflow to improve your deep-sky images



▲ **Charlotte's final image of the Sadr and Crescent Nebula region. Adding DSLR flat frames tackles flaws such as dust spots on your camera sensor or unevenly illuminated frames**

Getting the most out of our deep-sky data is a constant learning process. Not only do we need to master the complexities of capturing the data in the first place, but the art of post-processing is just as important. Between the data capture and processing stages lie calibration frames. They are integral as they allow us to overcome some of the limitations in our imaging setups, such as sensor noise, dusty lenses and vignetting. Reducing noise and vignette allows us to stretch our data further.

The two most common types of calibration frame are 'dark' and 'flat' frames. While dark frames reduce the noise in an image, flat frames help subtract anomalies in the image train, such as dust bunnies and vignette. Vignette presents as dark edges in the field of view (FOV) or an uneven field illumination, and can be due to lens/mirror design or something interfering with the light path in the image train.

▲ **An example of a flat frame, showing a brighter centre and vignetting at the corners**

It's good practice to add calibration frames to all astro images. First, we'll explain how to take these using a DSLR and then we'll explore how flat frames improve an image of the Sadr (IC 1318) and Crescent Nebula (NGC 6888) region of Cygnus.

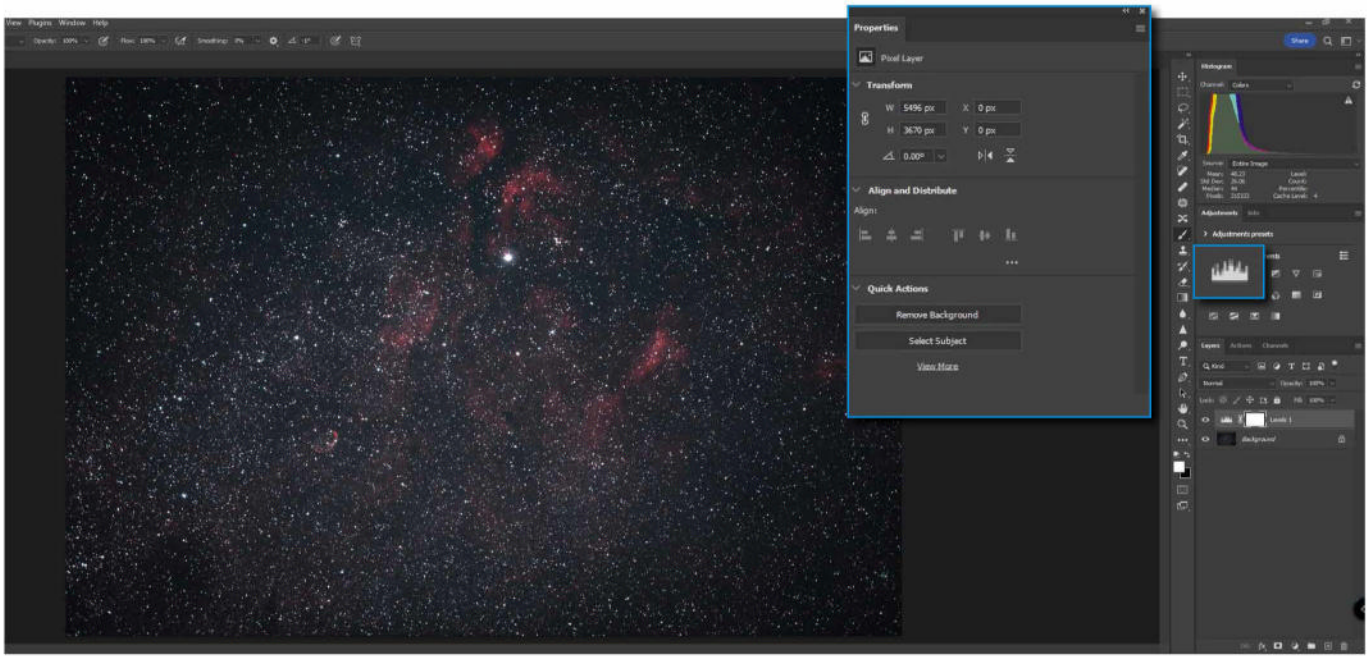
There are three main ways to take flat images: using a flat panel, a white T-shirt or a Word document. The best time to take them depends on the method that you use. Flat frames need to be taken at the exact same focus point as the light frames and with the DSLR set to 'aperture priority' (AV).

How to take flats

If using a flat panel, these flat frames can be taken directly after focusing and before you start the imaging run. If using the Word document method, take these once you've finished imaging. Carefully taking the OTA off its mount, carry it indoors, set the DSLR to AV and position the telescope in front of a blank Word document on your computer screen. Fire off 20–30 frames. Your flat frames should display a bright ring and dark corners.

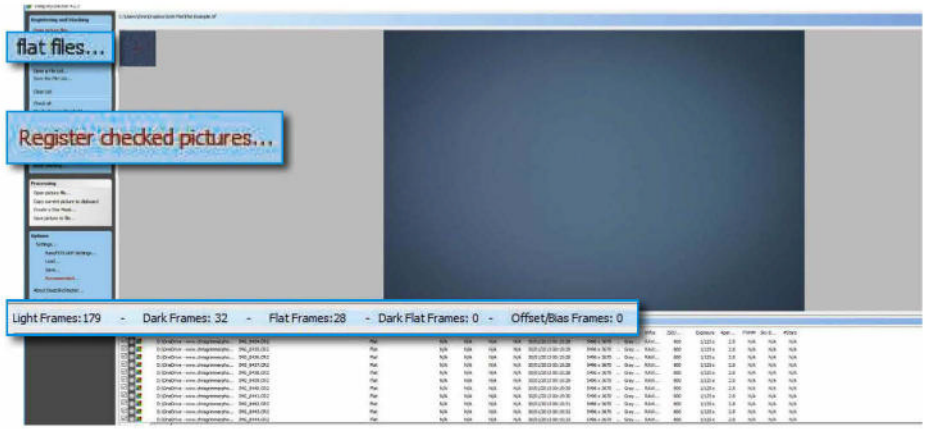
The white T-shirt method returns similar results, but the frames need to be taken the morning after the imaging session. Again, leave the focus in place overnight and wait until there's a bright early-morning sky. Gently place a white T-shirt over the front lens and secure it with an elastic band. Using the Sun as a light source, point your telescope towards it and take your flat frames.

ALL PICTURES: CHARLOTTE DANIELS



▲ Screenshot 1: The view in Photoshop of the stacked deep-sky image, processed without using flats. Despite adjustments via the Levels function, the corners remain too dark and the centre too bright. We need to go back to DeepSkyStacker to add in flat frames

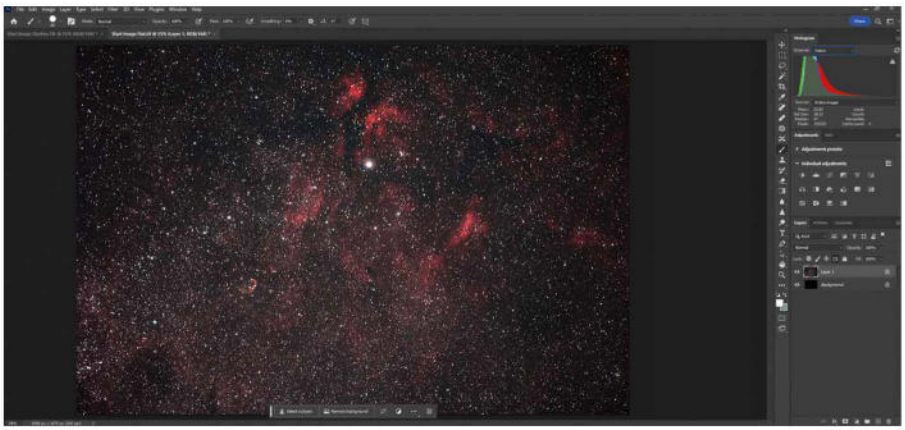
Turning to our example image of the region in Cygnus, we started with an unprocessed image without flat frames, stacked using DeepSkyStacker (DSS). We opened the image in Photoshop (File › Open › stacked file location) and used the 'Levels' function to stretch the data (Image › Adjustments › Levels). In Levels, we used the dropdown menu to select between red, green and blue channels, dragging the anchor points until they met the histogram (highlighted, Screenshot 1). Data began to emerge, but the corners were clearly dark and there was a bright zone in the middle of the image.



▲ Screenshot 2: With DeepSkyStacker, open the file again and add in all the DSLR flat frames. Register and stack the images and save the final result as a TIF file

Adding flats to the stack

It was time to re-stack the original images, but this time using our flat frames. Heading back to DSS, we added our previously captured light frames, then clicked on 'flat files' (highlighted, Screenshot 2). We navigated to our saved DSLR flat frames and selected them all (clicking Ctrl + A simultaneously), then clicked 'Check all'. Our calibration files appeared as registered in the bottom window of DSS. We then used DSS to register and stack the images and saved the final result as a TIF file.



▲ Screenshot 3: Returning to Photoshop, open the TIF file – now noticeably more evenly lit with the added flats – for processing, such as noise reduction and colour balancing

3 QUICK TIPS

1. If using the white T-shirt method, bright, clear skies without cloud will ensure an even field of view.

2. Try both the Word document and white T-shirt methods to see which works best for your setup and images.

3. Make it a habit to capture flat frames as part of every imaging session.

With the calibration frames added, we could process our new TIF image. Reloading in Photoshop, we performed the data stretch again, using the Levels function. The FOV of our image was now noticeably flat, with the corners as bright as the middle of our image (Screenshot 3). Final adjustments included colour balance (Image › Adjustment › Colour balance), noise reduction (Filter › Noise › Reduce noise) and the colour range (Select › Colour range) to reduce the size of the stars and produce our final image.

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

Your best photos submitted to the magazine this month

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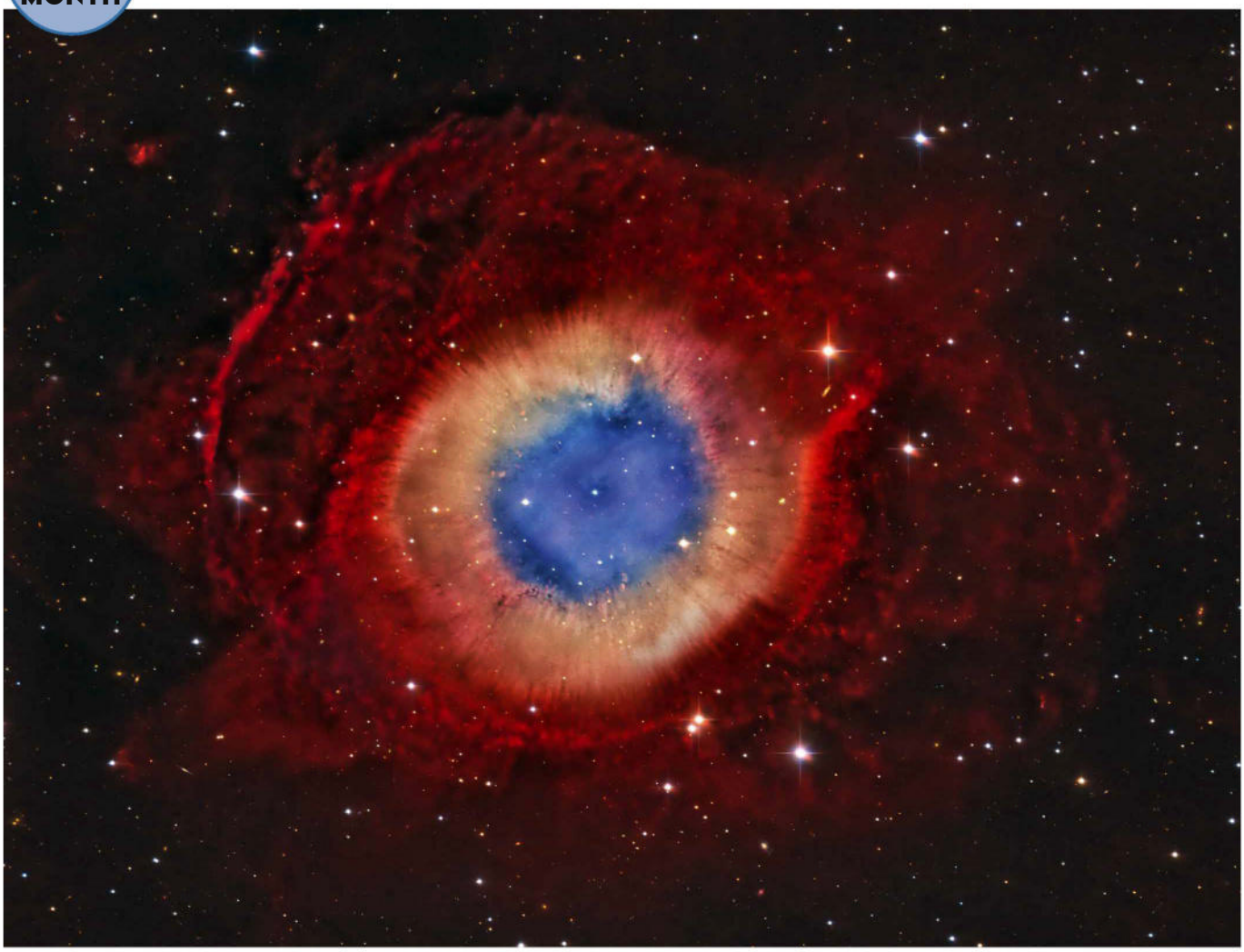
A gallery containing these and more of your images

PHOTO OF THE MONTH



△ NGC 7293, the Helix Nebula

Daniel Stern, remotely via DeepSkyChile, Rio Hurtado, Chile, 5, 7, 13, 14 and 15 June 2023

Daniel says: "I enjoy photographing planetary nebulae because these incredible objects present unique challenges in both data capture and in processing. This picture offers a view down a trillion-mile-long tunnel of glowing gases that were expelled by the central star. My desire in processing this image was to capture that perspective."

Equipment: Moravian C4-1600 camera, PlaneWave CDK 17" f/6.8 astrograph, PlaneWave L-500 mount
Exposure: 30x 120" R, 30x 120" G, 30x 120" B, 91x 300" Ha, 76x 300" OIII
Software: PixInsight

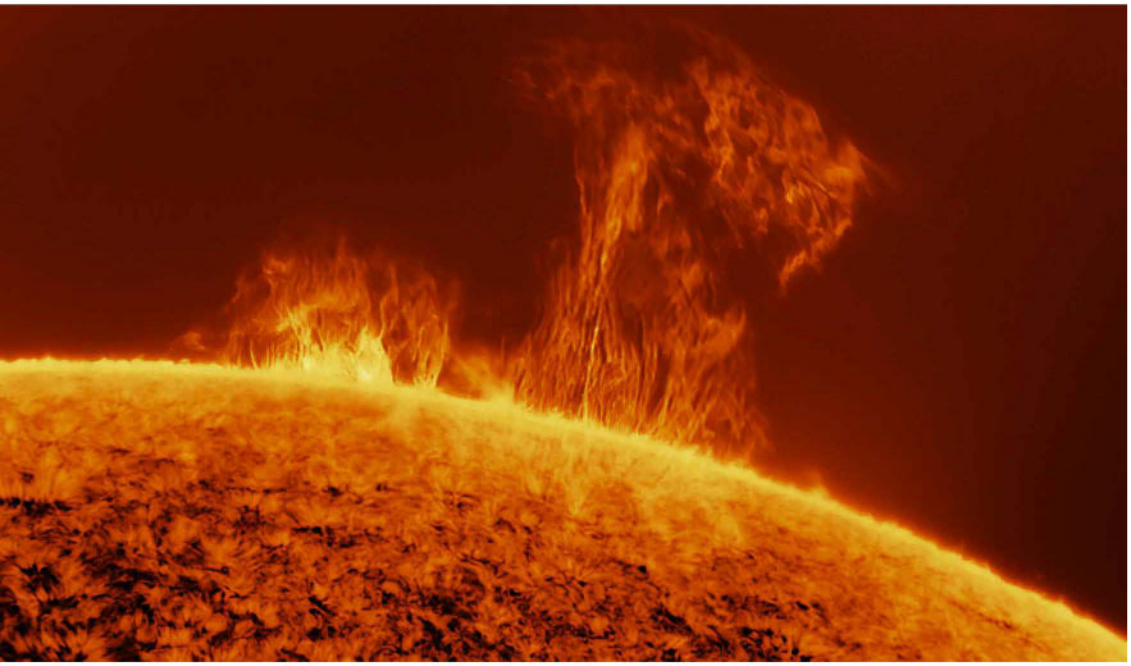
Daniel's top tips: "I've found that astrophotography is akin to the proverbial peel-the-onion analogy. The metaphor typically refers to slowly getting at the essence of something, but as I continue my journey in this hobby, its essence has proven elusive: as I peel back the many layers, the onion magically gets bigger! This image of the Helix Nebula is fitting to express that sentiment, in that the viewer is looking into a seemingly endless tunnel. I guess that's the ultimate allure of photographing the night sky: the possibilities are indeed endless."

M8, the Lagoon Nebula ▷

Jared Bowens, Missouri, USA, 20–23 June 2023

Jared says: "M8 is a fascinating nebula as it is visible to the naked eye. After seeing other amateurs' photos, I decided to see what I could capture."

Equipment: Canon 60D DSLR, Orion 8-inch f/3.9 imaging Newtonian, Celestron Advanced VX mount **Exposure:** 7h total **Software:** DeepSkyStacker, PixInsight, Photoshop



◁ The Sun

Arturo Buenrostro, Dallas, Texas, USA, 24 June 2023

Arturo says: "The fascinating thing about the Sun is that whenever one looks through the telescope, it will show a different and extraordinary landscape. The great activity of the solar cycle continues and is reaching its intermediate phase."

Equipment: Player One Apollo M-MAX mono solar camera, Lunt LS100MT solar telescope, Sky-Watcher EQ6 Pro mount **Exposure:** 1,500-frame video, best 50% of frames stacked **Software:** AutoStakkert!, RegiStax, Photoshop

The Milky Way over Mount Tymfi ▷

Tomas Slovinsky, Mount Tymfi, Greece, 24 June 2023

Tomas says: "I went to Mount Tymfi with my astrophotography workshop and we hiked for four hours to a mountain hut just below the Astraka peak. After several storms, clear skies appeared. At the beginning of the night, the Moon still illuminated the landscape, so you can see some nice details in the foreground."

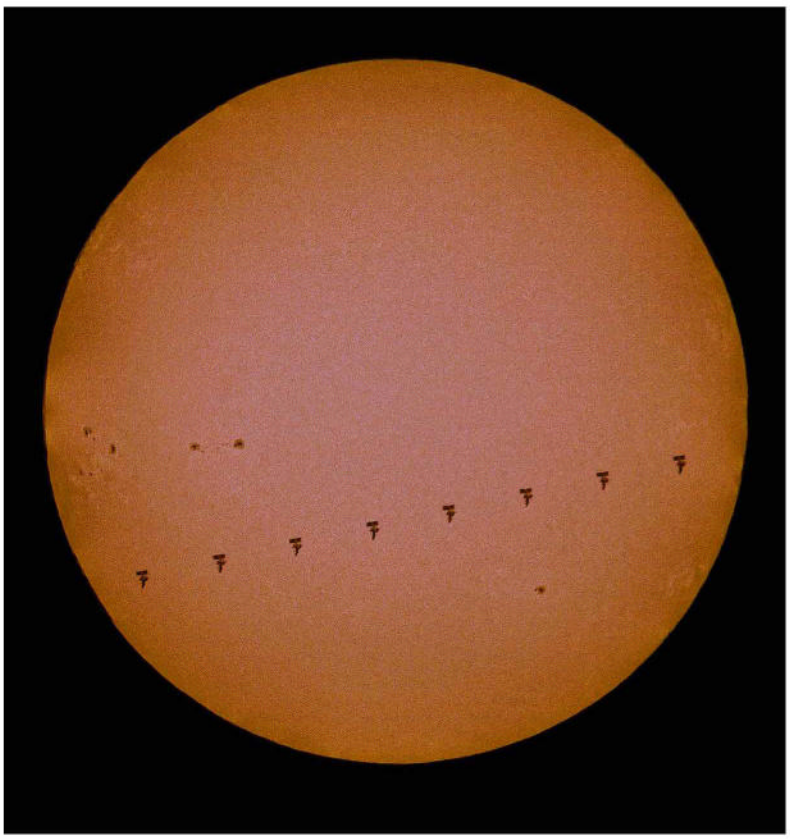
Equipment: Canon R6 mirrorless camera, Sigma 28mm f/1.4 DG ART lens **Exposure:** ISO 3200 f/2, 13" **Software:** Photoshop, Lightroom

M104, the Sombrero Galaxy ▷

Drew Evans, Flagstaff, Arizona, USA, 15–18 April 2023

Drew says: "The Sombrero Galaxy sits low in the southern sky in the Northern Hemisphere, so it was always a difficult target for me prior to moving to Arizona. This was taken over several evenings, totalling almost 15 hours of data."

Equipment: ZWO ASI2600MM Pro camera, Sharpstar SCA260 Cassegrain astrograph, iOptron CEM120 mount
Exposure: 40x 300" R, 40x 300" G, 40x 300" B, 50x 300" L
Software: AstroPixelProcessor, PixInsight



△ ISS solar transit

Graham Devenish, Upper Beeding, Sussex, 15 June 2023

Graham says: "I've wanted to do this since I started astrophotography, so I'm excited to have finally captured it! The ISS seems to be in an unusual alignment – maybe the solar panels on one side were facing in a different direction? The shot was planned using the ISS Transit Finder app."

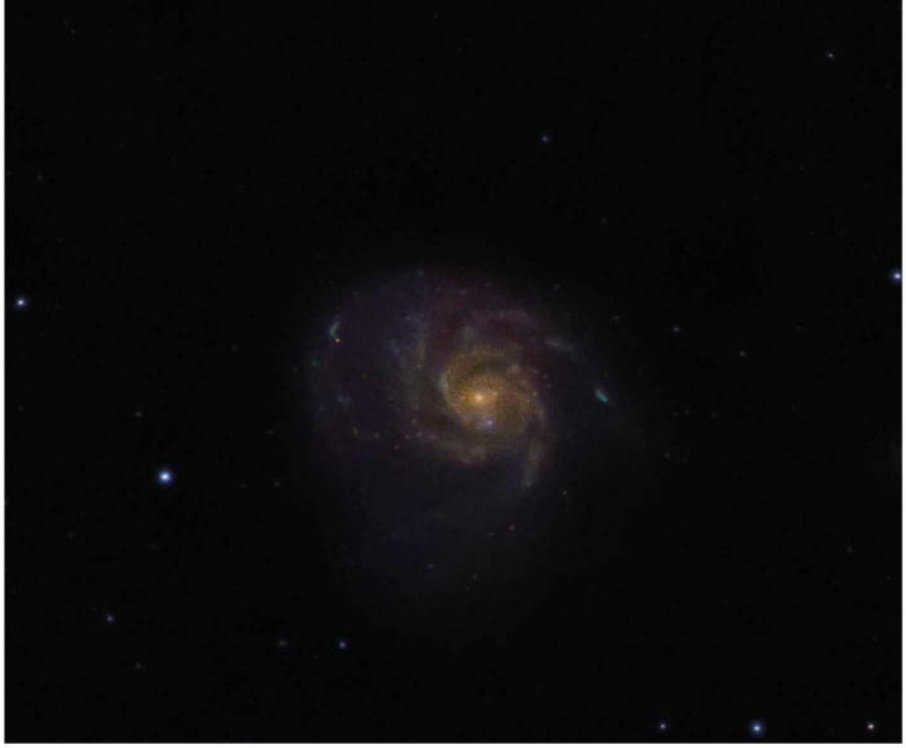
Equipment: Olympus OM-D E-M1X mirrorless camera, static tripod
Exposure: ISO 800 f/9, 8x 1/2,000" **Software:** Photoshop, Lightroom

▽ The Moon

Sonia Turkington, North Reddish, Stockport, 25 June 2023

Sonia says: "After a stormy afternoon, I quickly set up for the Moon before more clouds had a chance to head over. You can see the Lunar V and X nicely in the photo, which is completely unedited."

Equipment: Google Pixel 6 smartphone, Sky-Watcher Classic 250P Dobsonian reflector, integrated mount
Exposure: ISO 90 f/1.9



◁ M101, the Pinwheel Galaxy

Marina Amgad, Cairo, Egypt, 23–25 April 2023

Marina says: "It was my ardent desire to reimage this target now that I have an astro-photography telescope. I had to overcome a number of hurdles, as I'm imaging under a Bortle 9 sky and did not use any filters. I was a little taken aback when my photo turned out this good!"

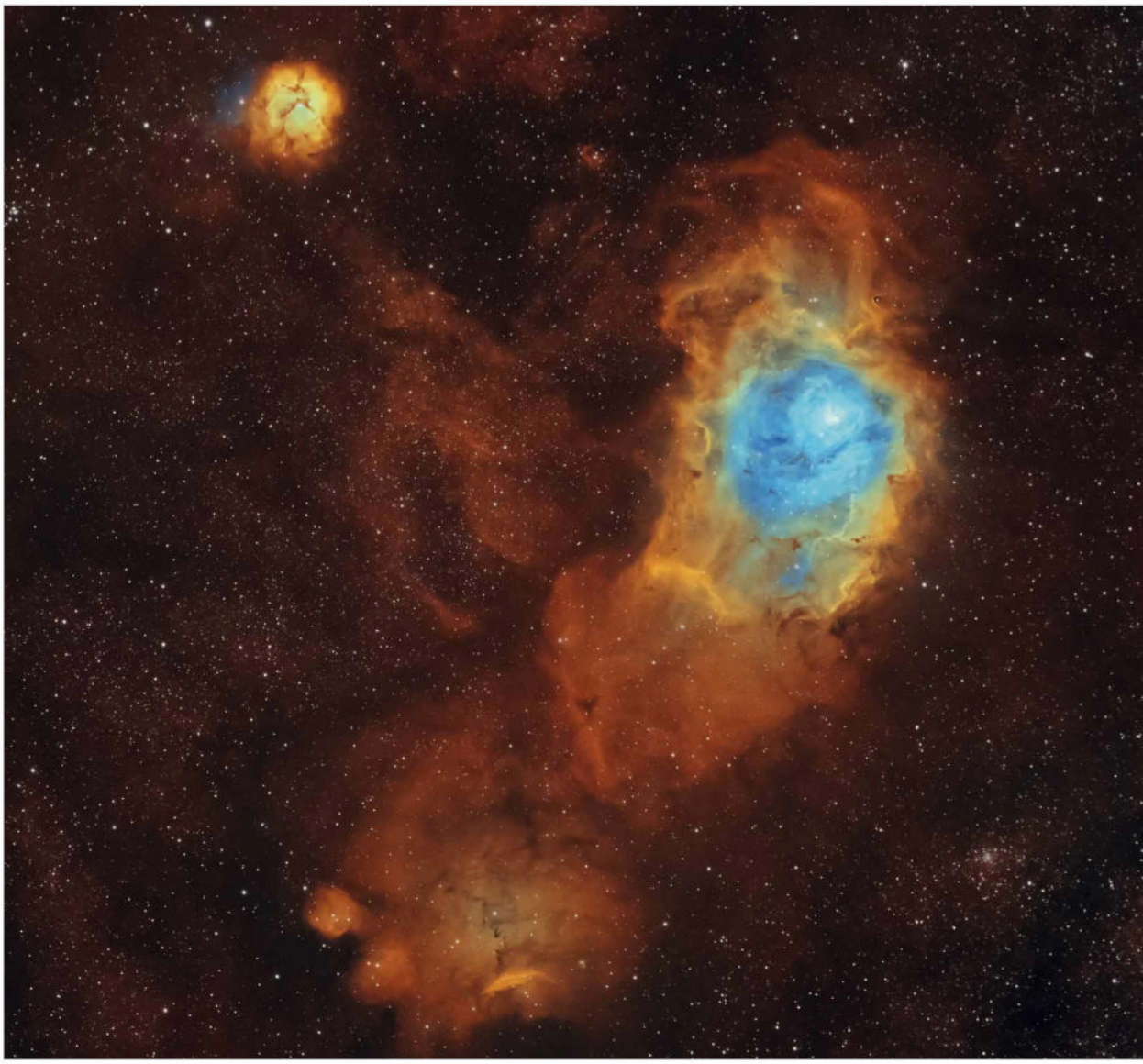
Equipment: Canon 800D camera, Sky-Watcher Evolux 62ED refractor, iOptron SkyGuider Pro mount **Exposure:** ISO 100, 635x 1' **Software:** DeepSkyStacker, Photoshop

The Lagoon and Trifid Nebulae ▷

Parth Patel, Ahmedabad, Gujarat, India, 21 and 23 April, 2, 10 and 11 June 2023

Parth says: "Clouds intervened to halt my imaging sessions, and when nights were clear, the humidity remained around 85 per cent. I couldn't risk using my cooled astronomy camera, fearing it might lead to condensation on the sensor."

Equipment: ZWO ASI533MM Pro camera, William Optics RedCat51 refractor, iOptron CEM26 mount **Exposure:** 24x 300" Ha, 24x 300" OIII, 24x 300" SII **Software:** AstroPixelProcessor, Photoshop



ENTER YOUR IMAGE

Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos

BBC Sky at Night MAGAZINE

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DEEP-SKY IMAGING SERIES

Join host and editor Chris Bramley for a three-part series of online masterclasses on deep-sky imaging and get the inside track on the dark art of revealing faint targets like distant galaxies and colourful nebulae at their most captivating.

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Registrants will also receive a link to view a recording of each talk after it has aired

Masterclass 1

How I got into deep-sky imaging

Hannah Rochford

In conversation with editor Chris Bramley, Hannah will talk about her journey from starting astrophotography in April 2021 to being awarded Best Newcomer at the Astronomy Photographer of the Year awards in September 2022.

Thursday 28 September, 7pm BST

Masterclass 2

Dealing with light pollution

Charlotte Daniels

Astro imager Charlotte will talk about ways to deal with the bright night skies experienced in urban and suburban settings, so that great images of deep-sky objects like distant galaxies and nebulae can be captured in all their richness.

Thursday 26 October, 7pm BST

Masterclass 3

A deep view of Orion

Tom O'Donoghue

The constellation of Orion is a familiar sight in winter skies and expert astrophotographer Tom will reveal how he captured and processed his remarkable large-scale, deep-sky image of it, the award-winning Orion Mega Mosaic.

Thursday 30 November, 7pm GMT

DZIKA MROWKA/ISTOCK/GETTY IMAGES, HANNAH ROCHFORD, CHARLOTTE DANIELS, TOM O'DONOGHUE

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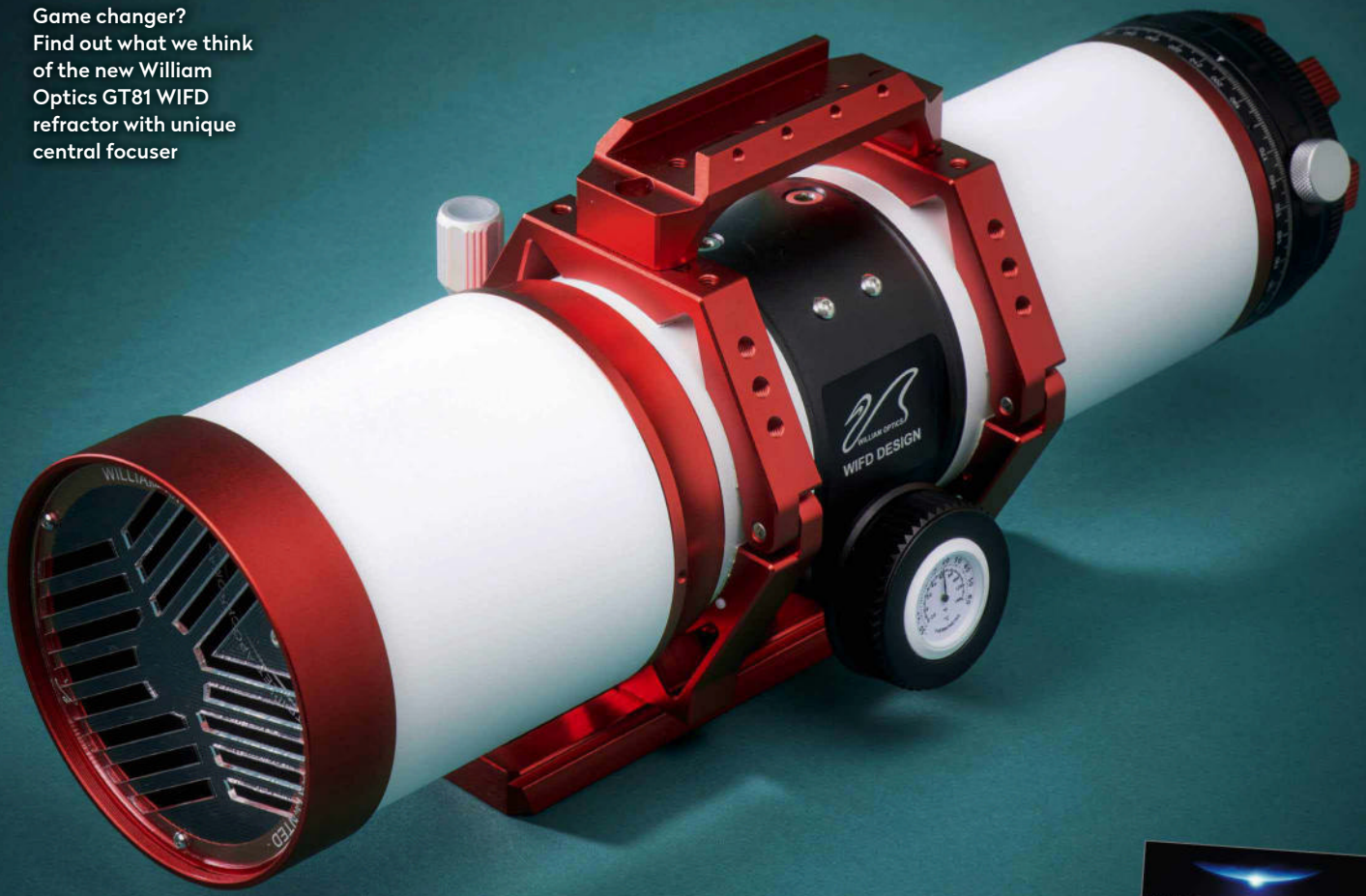
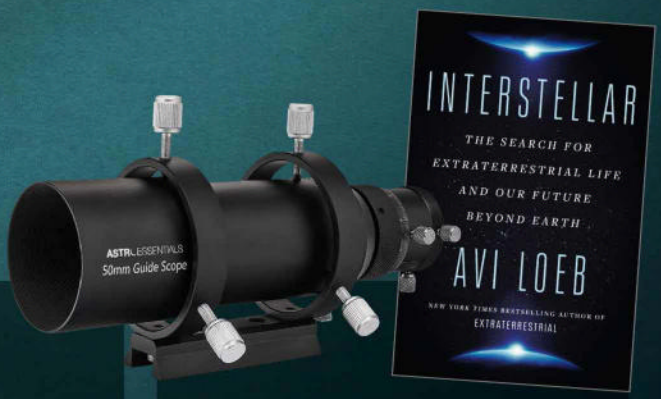
86

Game changer? Find out what we think of the new William Optics GT81 WIFD refractor with unique central focuser





HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: the latest must-have gadgets and new books on eclipse-chasers, extraterrestrial life, and more

@THESHED/PHOTOSTUDIO

William Optics Gran Turismo GT81 WIFD refractor

This version of the popular astrograph has a new twist: an innovative centre focuser

WORDS: CHRIS GRIMMER

VITAL STATS

- Price £1,749
- Optics Air-spaced triplet
- Aperture 81mm
- Focal length 478mm, f/5.9
- Focuser Dual-speed WIFD
- Extras Tube rings, Vixen dovetail bar, carry handle, carry case
- Weight 3.3kg; 4.5kg with accessories
- Supplier Widescreen Centre
- Tel 01353 776199
- www. widescreen-centre.co.uk

The William Optics GT81 refractor has been a popular stalwart of the brand for a long time – and for good reason. With a robust design and superb optics, it has proved a reliable workhorse for both visual and astrophotographic purposes. William Optics continually seeks to upgrade and optimise its designs and so, following in the footsteps of its latest RedCat innovations, we tested the new GT81 WIFD (William Optics Internal Focuser Design).

The GT81 WIFD arrived in a single box, with an optional field flattener arriving separately, which we were loaned for the review. We found the telescope securely enclosed in foam and well protected. While the optical tube assembly (OTA) we received for testing didn't include a carry case (it wasn't available at the time of review), we're pleased to confirm that this telescope will be shipped with William Optics's soft, padded carry case as standard.

One other thing to note is that no visual back adaptor is supplied as part of the standard package as this system is aimed at astrophotography, but the RotoLock visual back adaptor can be purchased separately.

The first thing we noticed with the WIFD model was, of course, the location of the large focus wheels, which sit squarely in the middle of the tube. The OTA is also wider than legacy GT81s to allow for the moveable lenses within, so it has the appearance of being short and squat. The finish is exceptional, comprising a white tube with red tube rings, lens cap and focuser. This model is also available with grey or gold accessories.

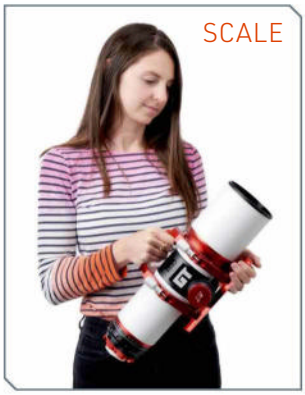
Focuser moves centre stage

Keeping with the original specification of the GT81, this is still an 81mm-aperture air-spaced triplet. At 478mm focal length (f/5.9), the GT81 is well suited for mid to large nebulae, even when paired with smaller imaging sensors, like our one-third-size CCD. The short focal length doesn't limit you to just nebulae. ▶

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Lens cap

The GT81 has a colour-coordinated, solid metal lens cap that includes William Optics's patented-design of Bahtinov mask. With the lens cap on the telescope, the mask is accessed by unscrewing the front, exposing the mask beneath. Having this connected to the lens cap reduces the risk of it being misplaced in the dark.



Tube rings/bar

Following on from its success with the RedCat series, William Optics has carried over its new accessory designs to the GT81. The standard package includes lightweight but solid tube rings, dovetail bar and combi carry handle/guider bracket, all finished in a choice of red, gold or grey.

Optics

The WIFD GT81 retains the trusted triplet setup of previous versions, comprising an 81mm main objective lens, three air-spaced lenses, FPL53 glass and ultra-high-transmission coatings. The FPL53 glass provides superb colour correction and removes the colour fringing often seen around brighter stars. When paired with the optional flattener, a beautifully flat field is returned.

Dew shield

The GT81 is equipped with a long, retractable dew shield, finished in white with red trim. This is constructed from aluminium and fits securely into place with a thumb screw. When we equipped it with our own dew heater strip to counter some very damp spring nights, we had no issue with dew forming on the optics.

WIFD focuser

Refractors typically have a fixed lens (or lenses) at the front of the telescope and place the focuser at the back of the tube. This system has worked well in the past, but with astrophotographic cameras getting larger, more sophisticated and heavier, there is always a risk of the focuser slipping, or even sagging, causing distortions to the images being captured.

The WIFD design (William Optics Internal Focuser Design) flips this on its head: the camera or eyepiece attaches directly to the barrel of the telescope, with the focuser situated in the middle of the OTA, where it adjusts the position of the front lens arrangement to achieve focus. This allows for extremely heavy cameras or eyepieces to be attached, with zero risk of unwanted focuser movement or slippage while imaging, or distortions caused by the focuser sagging. The focuser is smooth and responds to the touch without any 'sponginess'. This model is also equipped with slightly larger knobs, which allow for tiny adjustments to be made and precise focus to be easily achieved.

©THESHED/PHOTOSTUDIO X 3, CHRIS GRIMMER X 2

▶ Thanks to the FPL53 glass, the GT81 has a 95+ Strehl ratio, which ensures pinpoint stars and very sharp detail. This means that fine details can be resolved in both defuse globular clusters and dusty regions of galaxies.

Mounting the GT81 WIFD onto our Sky-Watcher EQ6-R, we did run into a small problem. The large focus wheels at the centre of the tube were pushed hard against the mounting saddle, stopping the mounting bar from being fully inserted and preventing the focus wheels from turning. To correct this, we had to remove the telescope from the tube rings and flip it upside down. This allowed the focuser wheels to be free, but resulted in the graduated focus scale becoming partially hidden. An additional dovetail plate could be another solution. Balancing the GT81 WIFD was simple, as without the weight of the focuser on the back, the balance point was mid-tube even with a camera and filter wheel attached.

Slewing up to our first target, we spent some time

KIT TO ADD

1. William Optics flattener 68III

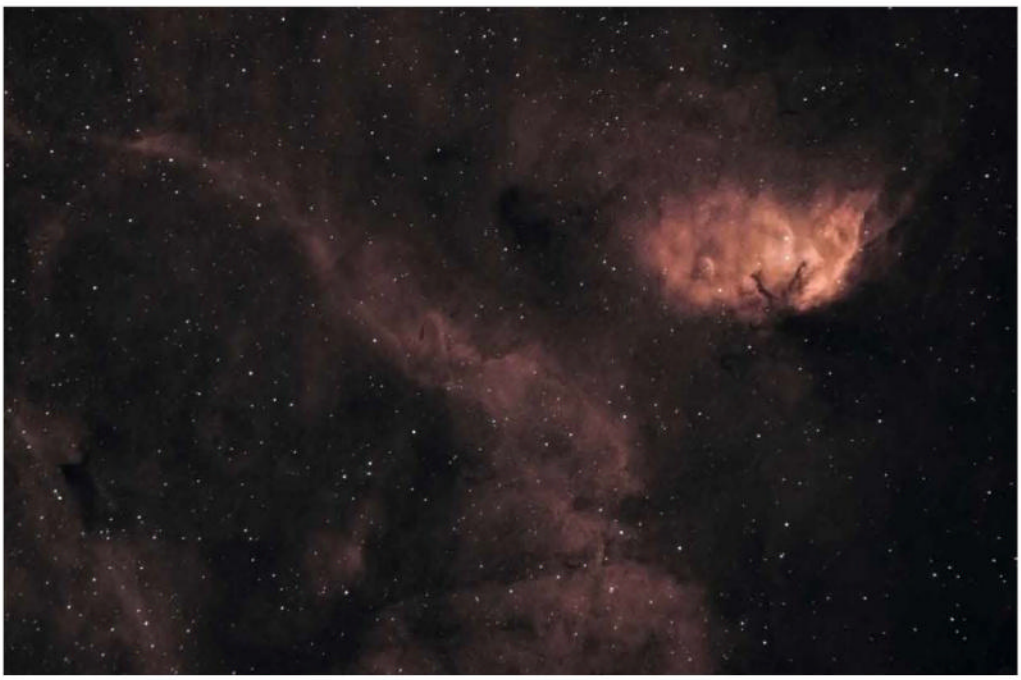
2. William Optics 50mm red guidescope

3. ZWO AM5 mount & tripod

Image rotator

Despite the focuser now being positioned at the midpoint of the telescope, William Optics has still included an image rotator. Made from black anodised aluminium, this rotates smoothly while maintaining enough resistance to feel solid. The fit of the rotator is such that there is zero risk of losing focus.

▲ The new design delivers pin-sharp, detailed images of clusters and nebulae. This Leo Triplet image was rendered from just 1h 30" exposures with a Canon 6D on board



◀ Some of the interstellar dust of the Tulip Nebula emerges from 30" exposures of 1 hour each of Ha and OIII, paired with a Starlight Xpress SXVR H694

trying to find focus; without the focus tube as a visual aid it was impossible to judge, especially with the image scale window being partially obscured due to the telescope being upside down. However, once close we found obtaining precise focus was easy, thanks to the silky-smooth focuser and the handy Bahtinov mask in the lens cap.

Sharp shooter

Our initial impression of the images was a flat field of view, with no vignette visible but some elongation of the stars into the corners. Attaching the optional field flattener corrected this further, with only slight elongation remaining. The optional spacing between camera chip and flattener has yet to be released by William Optics, so this may be corrected even further with accurate spacing.

The William Optics GT81 WIFD highlights the brand's forward-thinking approach to the world of astrophotography, while maintaining the excellent optics we now come to expect from its products. This is a telescope that is purposefully designed for large and heavy cameras, and it will certainly not disappoint.

VERDICT

Build & design	★★★★½
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★★½
Optics	★★★★½
OVERALL	★★★★½

Nirvana-ES UWA-82° eyepiece set

This ultra-wide five-piece set offers a worthy step-up from your kit eyepieces

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £95, £95, £85, £85, £85
- **Focal lengths** 16mm, 13mm, 10mm, 7mm, 4mm
- **Apparent field of view** 82°
- **Eye relief** 12mm
- **Optical elements** 7
- **Barrel size** 1.25mm
- **Extras** Dust caps, microfibre cloth
- **Weight** 170g each
- **Supplier** Optical Vision Ltd
- **Email** info@opticalvision.co.uk
- **www.**opticalvision.co.uk

Recently mechanically redesigned, Nirvana-ES UWA-82° eyepieces now have two more focal lengths added to the stable, bringing the set up to five. These range in focal length from 4mm to 16mm. The eyepieces all have a 1.25-inch-diameter barrel (threaded for filters), so will fit most common astronomical telescopes. We tested them using a 90mm f/13.9 Gregory-Maksutov telescope and a 130mm f/5 Newtonian telescope.

The whole set is specified to be parfocal, so little or no refocusing should be necessary when you change eyepieces. In practice, the 16mm and 13mm are parfocal with one another, as are the 10mm, 7mm and 4mm. They all have an apparent field of view of 82°, which means that the diameter of the eyepieces' field stop as seen through the eyepiece subtends an angle of 82° at your pupil. This angle includes a significant amount of your peripheral vision, so you need to 'look around' the field of view if you want to see detail in any specific part of it. This is because the part of your field of view in which you can discern useful visual information is only about 35° wide.

If you're new to ultra-wide eyepieces, it's worth mentioning the viewing technique to use. Approach the eyepiece with your viewing eye, stopping as soon as you can see the entire field of view in your peripheral vision. Your pupil is now at the eyepiece's exit pupil. If you move your eye to view parts of the field of view away from the centre, you will move your pupil away from the exit pupil, leading to 'kidney-bean' blackouts in your vision. Instead, you should 'roll' your head, ensuring that your pupil remains in the same place as you scan across the field of view.

A variety of views

The summer sky precluded testing the eyepieces on very faint objects, but initial testing on star clusters showed them to be sharp, with good contrast and colour fidelity. We took advantage of an eight-day-old Moon in unusually steady seeing to compare the eyepieces. Beginning with the 16mm and the Maksutov scope, we noted that the entire lunar surface was visible with space to spare, giving time ▶

Seven lens elements

The Nirvana-ES UWA-82° eyepiece set includes features that are usually only found in high-end eyepieces. Optical aberrations tend to become more pronounced with wider fields of view. Eyepiece designers mitigate this by introducing additional lens elements to reduce or eliminate these aberrations. The Nirvana UWAs have seven lens elements. Every additional piece of glass will absorb or reflect some light, so it is essential to reduce this loss of brightness. This is achieved by applying an anti-reflective multi-coating to every interface between air and glass.

If you look into the base of the eyepiece, you'll notice that there are baffles on the inside of the barrel. These eliminate image-degrading, spurious reflections off the barrel walls, helping to add contrast to the image that you see. What you cannot see is that (with the exception of the 4mm's field lens), the edges of the lenses are blackened. Lens edges are potentially a source of glare, so blackening the edges with low-reflectivity black paint will reduce the likelihood that you will be plagued by this effect.

ALL PICS: @THESHED/PHOTOSTUDIO

Similar weights

The specified weight is 170g and, despite their different sizes, all the eyepieces have a weight within 3 per cent of this (165–172g). As a consequence, there is no need to rebalance the telescope in its mount when you change eyepieces during an observing session.

Excellent ergonomics

The mechanical redesign of these eyepieces has resulted in the centre of gravity of all of them now being where the knurled rubber grip is located. There is therefore no sense of lopsided weight distribution when you pick them up or remove them from the telescope.

Soft rubber eye-cups

Eye placement is critical in ultra-wide-angle eyepiece designs; the soft rubber eyecups help with this. We found that the ideal eye position was just short of touching the eyecup, so the soft rubber gives you a gentle reminder if you get too close.

Tapered undercut

The eyepiece barrel has a slightly tapered undercut. This will not only prevent the eyepiece from falling out if the eyepiece holder isn't fully tightened, but will also tend to pull the eyepiece fully into the holder as it is tightened, which is a useful trait for parfocal eyepiece sets.

Dust prevention

The eyepieces have caps for both ends to keep dust at bay and each eyepiece is provided with a microfibre cleaning cloth. Soft microfibre, which is even finer than silk, is the preferred material for cleaning optics so, if the lenses do get dirty, you have the means to clean them.

▶ to appreciate the view as the Moon slowly drifted across it. We got very crisp views with this eyepiece, but possibly some softening of the image near the edge of the field of view. With the Newtonian, the view was crisp in the central 75 per cent, but the edge softness was more apparent.

Turning to the 13mm, with the Maksutov we found a similar view to the 16mm, with slightly more detail revealed. We couldn't discern any edge-softening. However, in the Newtonian the edge-softening was more visible. We swapped to the 10mm in the Maksutov, and wow! Detail along the terminator really began to pop, and in the Newtonian the craterlets in Ptolemaeus looked good. With this eyepiece, edge-softening was not detectable.

Changing to the 7mm in the Maksutov, we saw a beautifully crisp image, and lunar sunrise along the terminator was mesmerising. We saw sublime shadow-play in crater Arzachel and the central peak of Alphonsus casting a sharp, pencil-thin shadow to the crater's edge. In the Newtonian, the shorter focal length didn't compromise the 7mm, with lovely, sharp detail everywhere. A gorgeous eyepiece!

Finally, we turned to using the 4mm. In the Maksutov, this provided too much magnification (313x) even with steady seeing. However, with the Newtonian (163x) there were crisp, detailed views but distinctly less contrast than the 7mm in the Maksutov. We noted glare when the Moon was just outside the field of view, which was not present in the other eyepieces, suggesting an unblackened lens edge might be the culprit.

In general, these are good-value eyepieces, but note that there is insufficient eye relief to enable the full field of view to be visible if you wear spectacles. Also, the 2.5mm lettering makes it difficult to see the printed focal length in dim light. If you're seeking a significant step-up from eyepieces that come bundled with a telescope, you will appreciate the Nirvanas. And if you only want one, make it the 7mm!

VERDICT

Build & design	★★★★½
Ease of use	★★★★½
Extras	★★★★★
Eye relief	★★★½☆
Optics	★★★★½
OVERALL	★★★★½

KIT TO ADD

1. OVL 1.25-inch light pollution filter

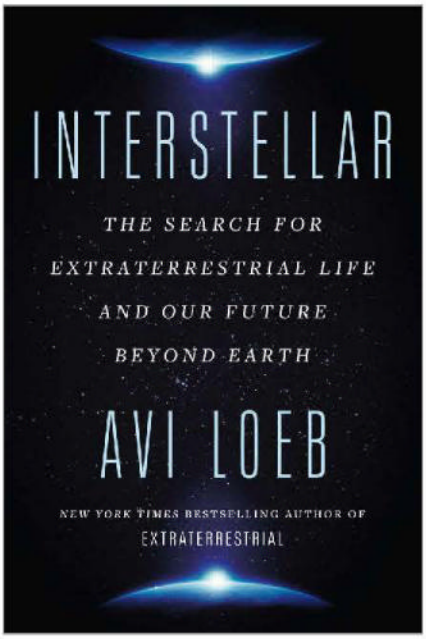
2. OVL 1.25-inch lunar/planetary filter set

3. OVL 1.25-inch variable polarising filter

ALL PICS: @THESHED/PHOTOSTUDIO

New astronomy and space titles reviewed

BOOKS



Interstellar

Avi Loeb
John Murray
£20 ● HB

The central argument of *Interstellar* is that humanity is unprepared for the realisation that advanced extraterrestrial civilisations are common, and that we have not even begun to explore that possibility to the full extent of our capabilities.

Theoretical physicist Avi Loeb introduces us to the Galileo project whose aims are: to obtain high-resolution, multi-spectral images of Unidentified Aerial Phenomena (UAP); to design a launch-ready space mission that can intercept and image objects of known interstellar origin; and recover one of only two known meteorites of interstellar origin off the coast of Papua New Guinea.


ILLUSTRATION

Loeb doesn't rule out 'Oumuamua, 2017's weird interstellar visitor, being extraterrestrial in origin

EUROPEAN SOUTHERN OBSERVATORY/M. KORNMESSER

Although these aims are admirable, and possibly warranted, it is still a leap of faith to conclude that anything unexplained or anomalous is due to alien intelligence. Much is made of the discovery of 'Oumuamua, an odd-shaped asteroid-like object that briefly visited the Solar System in 2017. 'Oumuamua was indeed strange, but that does not support the assertion that it was of alien construction.

For example, in the opening chapter Loeb states, "We live in a time... of mounting evidence that we are not alone". Later he writes that "We have never been so close to scientifically valid proof..." – a clear admission that there is, as yet, no evidence for the fundamental assertion of the book. This is not how science works; there is evidence or there is not. We cannot almost have evidence.

However, *Interstellar* contains a wealth of interesting and timely discussions of humanity's readiness to accept confirmation of our membership of the assumed interstellar fraternity. It examines unexplored avenues in SETI (Search for Extraterrestrial Intelligence) research and advocates for a fundamental change in our view of the Universe and its exploration. We touch on ethics, philosophy and futurism, humanity's chances of survival, artifical intelligence and the possibilities for galactic migration. Interestingly, it also makes a strong case for advancing our capabilities of discovering the missing evidence of alien civilisations. This is a book that will appeal to anyone with even a passing interest in the most fundamental question there is.

★★★☆☆

***Alastair Gunn** is a radio astronomer at Jodrell Bank University*

Interview with the author

Avi Loeb

How would we react to the discovery of signs of life beyond Earth?

Any object we find would likely be more advanced than our technology, because the senders reached our doorstep before we reached theirs. The discovery of an extraterrestrial device would be accompanied by a sense of awe. It's an opportunity to make a leap towards our technological future. With a grander view, we could change our priorities from those of a crow pecking on the neck of eagles to becoming an eagle that rises to heights where no crows survive. Here's hoping we move away from the crow mentality on social media to the eagle mentality of intelligent civilisations in interstellar space.

What are our best methods?

Listening to radio signals is similar to waiting for a phone call. You need the counterpart to be active. The approach I am taking is to check for physical objects that arrived on our doorstep from our cosmic neighbourhood. Even if their senders are dead, we would still retrieve them. Moreover, packages would accumulate, whereas radio signals are billions of lightyears away if they were sent billions of years ago.

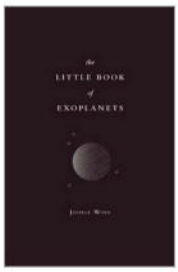
Where should we focus?

We invest billions of dollars in the search for dark matter. But the public cares more about "Are we alone?" than about the nature of dark matter. We should invest similar resources, or more, in the search for interstellar objects of technological origin. Science can be exciting if it resonates with the public interest.

***Avi Loeb** is the head of the Galileo Project and founder of Harvard University's Black Hole Initiative*

The Little Book of Exoplanets

Joshua Winn
Princeton University Press
£18.99 ● HB



It could be very easy for a book about exoplanets to become a victim of the field's own breakneck pace of discovery, yet *The Little Book of Exoplanets* masterfully avoids this fate. By focusing on what we know and maintaining a keen awareness of what we don't know, Joshua Winn's primer on exoplanet science expands outwards from our neighbouring Solar System worlds to strange and unexpected exoplanetary finds, concluding with upcoming missions and projections on near-future methodologies and subfields of interest.

Throughout the book, the scientific method provides the author's guide. For example, Winn does not merely present the 51 Pegasi b discovery as a simple historic first; instead, he details the history of potential detections and pulsar planets. For each, he considers the methodology used and whether astronomers had justified true beliefs that those detections constituted exoplanets, sharing the important lessons learned on the complicated path to exoplanet discovery.

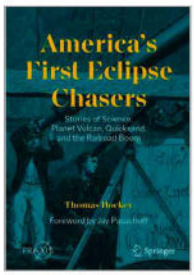
From explaining theories of hot Jupiter migration to why exoplanet orbits can end up in musical resonances, *The Little Book of Exoplanets* opens up a Universe that is extraordinary and enticing. With a fair amount of maths and complex graphs to interpret, this book may not be suitable for every reader, but equally it is refreshing that Winn trusts his audience enough to dive into the data and show them the true work of an astronomer: making sense of figures. It is this focus on process that gives this work the potential to be an exoplanet classic with staying power.

★★★★½

***Emma Johanna Puranen** is a postgraduate researcher with the St Andrews Centre for Exoplanet Science*

America's First Eclipse Chasers

Thomas Hockey
Springer
£27.99 ● PB



It was 1869, four years after the end of the American Civil War and the abolition of slavery, that astronomical interest peaked in America, as thousands flocked to see a total eclipse that travelled from Alaska through the middle of the US to the East Coast. This book tells the story of those eclipse chasers, from the official expeditions by universities and the US Naval Observatory to the informed citizens who learned about the eclipse from their local newspaper or their church preacher.

Hockney tries to include a diverse range of characters in his story and is open about the difficulties he encounters trying to tell that balanced story. The voices of Native American observers for example, were hard to find, their story instead told through the accounts of white observers.

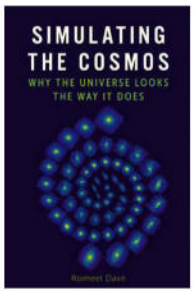
Though he finds examples of recently freed enslaved people viewing the eclipse, again he has to use unreliable second-hand accounts of their reactions. Including the voices of well-educated, astronomically-minded white women proved simpler, thanks to Maria Mitchell's delegation of all-female observers from Vassar College.

There's a lot of information in this book, not only about the people: the science is also well explained. There's also a good deal of information about American geography and history, including the not inconsequential fact that chasing the eclipse brought many North American astronomers to the South for the first time. All of this makes for a fascinating book, almost certain to teach any reader something new. ★★★★★

***Emily Winterburn** is a science writer, physicist and historian of astronomy*

Simulating the Cosmos

Romeel Davé
Reaktion Books
£15.95 ● HB



In an era when we're able to capture so much data on the real Universe, just what is the point of simulating artificial universes in a computer? Romeel Davé starts his concise and well-written book by explaining the fundamental limitations of observational astronomy: even with the best telescopes imaginable we will never be able to watch individual galaxies form and evolve because of the cosmic timescales involved; and we will never be able to view these objects from more than one line of sight because of the immense distances between us and them.

But what we can do is model these distant targets on computers, and in *Simulating the Cosmos* cosmologist Davé, who has spent his professional life doing just that, takes us through the A to Z of these simulations.

After an introductory chapter that sets the scene with an explanation of the standard 'concordance' model of cosmology, the book then delves into the nuts and bolts of how computer simulations actually work. These technical aspects are clearly elucidated and we're made privy to the pros and cons of different techniques and their resulting successes and failures. Of course, it's the latter that drives the science onwards, such as the inability of simulations to account for observed galaxy structures (such as the Milky Way's barred spiral), and here Davé draws the book together by describing how relatively small-scale processes within galaxies can actually affect cosmological variables.

This is an enthralling read that is highly recommended to readers, including prospective astrophysicists, keen to understand more about how modern cosmology is actually accomplished.

★★★★★

***Pippa Goldschmidt** is an astronomy and science writer*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Astro Essentials 60mm guidescope

Price £99 • **Supplier** First Light Optics
www.firstlightoptics.com

The long focal length of this guidescope means it's compatible with almost all guide cameras, while its wide field of view and fast f/4 focal ratio means you should easily be able to pick out a guide star. Guide cameras can push-fit into the 1.25-inch eyepiece clamp or screw in via the integrated M42 thread.

2 Legami eraser set

Price £4.50 • **Supplier** Cult Pens
www.cultpens.com

Each of these colourful erasers are shaped to look like one of the eight major planets, plus a rocket to visit them in. A wonderful gift for space-enthused children as they head back to school.

3 Askar 5-in-1 M54 filter drawer

Price £155 • **Supplier** 365 Astronomy
www.365astronomy.com

Swap between filters with ease using this drawer system, which has a unique five-in-one design that can fit any of the most commonly used sizes of filter: 1.25 inch, 31mm, 36mm, 2 inch or 50mm. Its slimline design slots unobtrusively into your imaging setup.

4 Omegon polar wedge EQ-platform

Price £394 • **Supplier** The Widescreen Centre
www.widescreen-centre.co.uk

Tracking with a Dobsonian can be a pain, but this motorised platform allows one to follow the motions of the sky for up to an hour before needing to be reset. It can support telescopes up to 30kg, weighs just 3.5kg and requires a single 9V battery.

5 Osprey Daylite waist pack

Price £24 • **Supplier** Ordinance Survey
www.shop.ordnancesurvey.co.uk

Keep your essentials close to hand when out observing with this waist pack. Made from sturdy recycled nylon with two zip-up compartments to keep your accessories secure and safe from the elements.

6 Altair 2nm G-band solar contrast filter

Price £179.50 • **Supplier** Altair Astro
www.altairastro.com

Enhance the finer details in the solar photosphere with this G-band filter, which brings out the structure of sunspots and makes granulation clearer. Must be used with a suitable, safe white-light solar filter or Hershel wedge.

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Anita Chandran interviews Dr Lalitha Sairam

Q&A WITH A PLANET HUNTER

BEBOP-1c is the second 'Tatooine' world found orbiting its twin stars, making it one of only two circumbinary systems so far known

What is a circumbinary system?
Binary systems refer to two stars orbiting around a common centre of mass and, in general, circumbinary systems are ones where a planet orbits around a pair of stars, rather than orbiting around a single star. There is another type of binary planet system where a planet orbits around just one star in a binary pair.


ILLUSTRATION

▲ Not science fiction any more: the gas giant BEBOP-1c is the second planet found orbiting the double suns of the TOI-1338 system

How many of these systems have been detected so far, and are they rare?
There have been about 14 transiting planets discovered orbiting around 12 binary stars. They are quite rare primarily because of our limitations in observing them and validating them, all of which require tremendous amounts of time. As you go out and look at the night sky, nearly 75 per cent of the stars you see are in multiple systems, so binary stars are quite common. If we extrapolate from what we know about single stars, we should be able to discover many more planets in circumbinary systems using improved techniques and improved telescopes.

What did your investigation involve?
Our idea was to carry out something known as 'radial velocity measurements' of binary stars, as part of a survey called Binaries Escorted By Orbiting Planets (BEBOP), observing in both the Northern and Southern Hemispheres. In 2020, there was an announcement that the Transiting Exoplanet Survey Satellite (TESS) had observed a circumbinary planet in a system called TOI-1338 b.

We immediately began to look for this planet, but we didn't have enough observing time to be able to see it, so we made further observations of the system with the European Southern Observatory's Very Large Telescope (VLT). When we started analysing the data, what we saw wasn't the planet that was announced initially, which had around a 95-day orbital period; instead we started seeing a signal around 220 days. Through further analysis, the signal started to become more prominent and this 220-day orbital period planet is now called BEBOP-1c, making it the second-ever discovery of a multiplanetary circumbinary system.

What is the 'radial velocity method' you used to detect BEBOP-1c?
We know that two bodies in orbit exert a gravitational pull on one another. When you sit here on Earth and observe a star–planet system, the gravitational tug-of-war happening causes the star to wobble, shifting the light from the star towards and away from you. This is called redshift and blueshift. By measuring the size of the shift, you can measure how massive the body is that is exerting the gravitational pull. This is how the first-ever exoplanet, 51 Pegasi b, was discovered.

What can scientists and society learn from studying circumbinary planets?
They challenge our ideas of how planets are formed. We see these planets are formed in more complex environments, so their formation process may be quite different compared to what we have known. But generally, what's interesting for people that have watched *Star Wars*, is that BEBOP-1c is a 'Tatooine-like' planet. Tatooine is the fictional home of *Star Wars*'s Luke Skywalker and it has two suns and two sunrises. On BEBOP-1c – if the planet had a surface – then you would see two sunrises, just like on Tatooine. Unfortunately, the parallels end there, but it's a nice way for people to look at astronomy as a mix of fiction that they can relate to real life.

Could a planet ever have three stars?
There have been measurements suggesting there could be planets orbiting around three stars, but no conclusive evidence as of now. It is the case that maybe these planets will be further away from the star itself for them to survive – if they're very close, the gravitational pull from three stars is going to be too unstable for the planet to survive – and this means there would be long waiting times for us to be able to detect these planets.

Lalitha Sairam is a postdoctoral fellow at the University of Birmingham working on the discovery and characterisation of exoplanets

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch sight of brightening comet 2P/Encke before sunrise and explore little-known Microscopium

When to use this chart

1 Sept at 00:00 AEST (14:00 UT)
15 Sept at 23:00 AEST (13:00 UT)
30 Sept at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

SEPTEMBER HIGHLIGHTS

Comet 2P/Encke is one of the shortest-period comets (3.3 years) and has been observed for over 300 years. It's best observed in the early dawn above the northeastern horizon. Starting the month in Auriga, it heads towards Castor, being closest on the 12th (1° north), around 10th magnitude. The 22nd sees Encke around ninth magnitude, just above the horizon, an hour before sunrise. It continues to drop into the dawn glow until it's lost, reaching perihelion next month.

STARS AND CONSTELLATIONS

September skies present a wonderful contrast: the western half displays Milky Way vistas preparing to leave the evening, with icons like Scorpius dropping towards the horizon and Sagittarius's Teapot too, spout first. This gives way to the home of galaxies, a sparse sky with luminaries like Achernar and Fomalhaut or constellations Grus and Pegasus being exceptions. Other signposts like Piscis Austrinus and Capricornus are distinctive, but need dark skies to see.

THE PLANETS

With Mars now departing as twilight closes, the evening highlight is Saturn high in the northern sky, transiting around 23:00 (mid-month). Around this time Jupiter is rising, followed 30 minutes later by Uranus. Both are best observed in the morning. Neptune reaches opposition, transiting around midnight and visible all night. Venus can't be missed, rising in the eastern predawn sky. Although unnoticeable, this already-glowing beacon reaches maximum illumination on the 19th.

DEEP-SKY OBJECTS

This month we take a trip to the obscure constellation of Microscopium, located south of Capricornus. Its brightest luminaries are a handful of fifth-magnitude stars, which include Alpha Microscopii (RA 20h 49.9m, dec. –33° 47'), an impressive double star. It has an obvious yellow primary (fifth magnitude) with a white secondary (10th magnitude) lying 20 arcseconds away.

Moving 3.7° northwest of Alpha finds the galaxy NGC 6925 (RA 20h 34.3m, dec. –31° 59'). This 11th-magnitude near-edge-on spiral has an obvious halo with a bright elongated core and star-like nucleus. Compare this to galaxy NGC 6958 (RA 20h 48.7m, dec. –38° 00'), 4.2° south of Alpha. It's also 11th-magnitude but elliptical, showing a near-circular halo (2 arcminutes wide) with a broad core that brightens towards the centre.

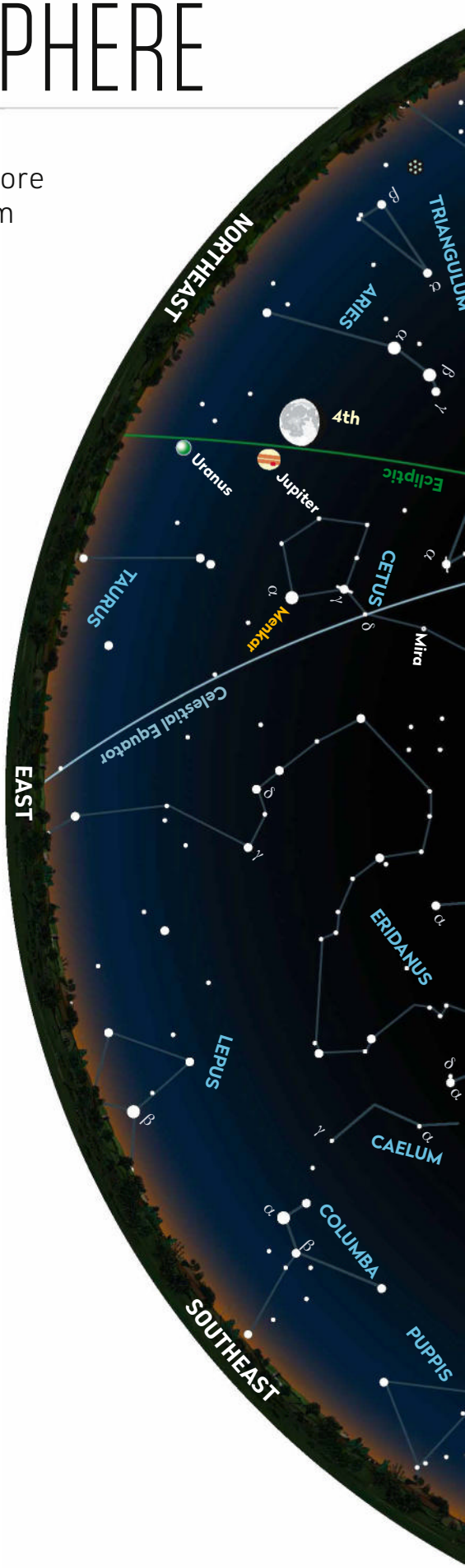

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Deneb
Cocoon Nebula
N. America Nebula
NGC 7027
M39
M29
CYGNUS
LACERTA
M31
M32
M110
ANDROMEDA
Blue Snowball
Alpheratz
Veil Nebula
Dumbbell Nebula
Northern Cross
Albireo
Summer Triangle
LYRA
Ring Nebula
M33
PISCES
PEGASUS
Great Square of Pegasus
DELPHINUS
SAGITTA
VULPECULA
Coathanger Cluster
EQUULEUS
M15
Enif
Circlet
30th
Water Jar
Altair
AQUILA
Rasalhague
AQUARIUS
M2
1st
Neptune
27th
Saturn
CAPRICORNUS
SERPENS CAUDA
M11
SCUTUM
Deneb Kaitos
NGC 253
Fomalhaut
M30
MICROSCOPIUM
Pluto
NGC 6925
24th
M25
M16
M17
M22
M23
M20
M18
OPHIUCHUS
M10
M12
SCULPTOR
PISCIS AUSTRINUS
NGC 300
PHOENIX
NGC 6958
GRUS
FORNAX
SAGITTARIUS
Teapot
INDUS
CORONA AUSTRALIS
M7
M6
M19
21st
Ro
Achernar
NGC 362
TUCANA
47 Tucanae
PAVO
M62
Antares
M4
HOROLOGIUM
HYDRUS
SMC
RETICULUM
Tarantula Nebula
ARA
SCORPIUS
TRIANGULUM AUSTRALE
NORMA
DORADO
OCTANS
LUPUS
LIBRA
PICTOR
MENSA
LMC
South Celestial Pole
CHAMAELEON
APUS
CIRCINUS
Rigel Kent
Canopus
VOLANS
NGC 4833
Agena
MUSCA
Southern Pleiades
CENTAURUS
CARINA
Coal Sack
Jewel Box
Ro
η Carina Nebula
CRUX
Blue Planetary Nebula